US-191, Colorado River Bridge Study

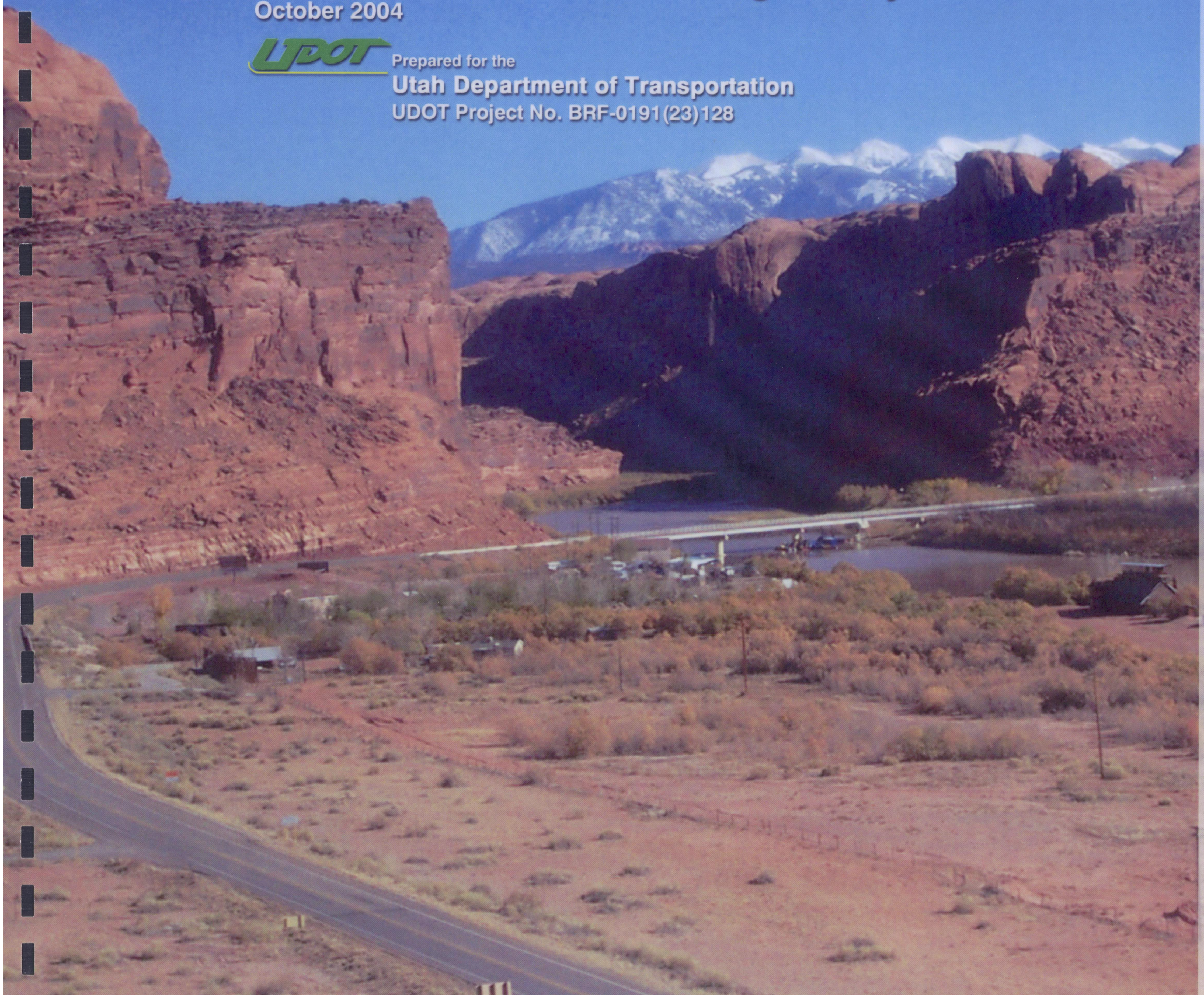
October 2004

UDOT

Prepared for the

Utah Department of Transportation

UDOT Project No. BRF-0191(23)128



HDR

US-191, Colorado River Bridge Study

Prepared for:

Utah Department of Transportation

UDOT GOING THE EXTRA MILE

October 2004

Prepared by:

HDR Engineering, Inc.

HDR

LICENCED PROFESSIONAL ENGINEER
No 350971
GERALD C.
GODZWON
Nov. 10, 04
STATE OF UTAH

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

1.1 Study Purpose

The purpose of the US-191, Colorado River Bridge Study was to investigate the structural efficiency of the bridge and the feasibility of reconstructing the bridge and/or improving the function of the bridge. Feasibility is defined by cost, technical difficulty, major impacts, and user benefit. More specifically, the purposes of this study are as follows:

1. Examine current traffic demand along US-191, both north and south of the bridge.
2. Determine the future travel demand across the Colorado River Bridge and the roadway cross-section necessary to accommodate the demand.
3. Develop conceptual bridge design alternatives based on evaluating the possible horizontal alignments, environmental issues, traffic data, scour issues, geotechnical recommendations, cost, construction issues, and future maintenance and inspection requirements.
4. Develop preliminary bridge Situation and Layout sheets.
5. Make a recommendation about whether the bridge should be widened, rehabilitated, or demolished and replaced.
6. Identify whether improvements are necessary for the turnoff at SR 279 (Potash Road) between Arches National Park and Moab.
7. Identify whether improvements are necessary for the turnoff at SR 128 just south of the Colorado River Bridge.
8. Initiate National Environmental Policy Act (NEPA) scoping, purpose and need, and agency coordination to help this study transition into a subsequent environmental document for the river crossing.

1.2 Study Procedure

This study was carried out by HDR Inc. through a contract with and under the direction of the Utah Department of Transportation (UDOT). This study included public and agency scoping meetings, origin and destination surveys, examination of current traffic demand along US-191 (both north and south of the bridge), alternative crossing locations, determination of future travel demand across the Colorado River Bridge, consideration of the existing bridge and its condition and safety standards, and evaluation of bridge alternatives.

1.3 Background and History

The Colorado River Bridge Study is an analysis of the US-191 crossing of the Colorado River near Moab, Utah. The bridge was constructed in 1955. Although the bridge is currently structurally reliable, it is beginning to deteriorate with age. If it continues to deteriorate, it will no longer be able to accommodate vehicle travel, unless it is repaired and rehabilitated as discussed in Section 8.1.1. Additionally, because the bridge is 50 years old, it does not meet current bridge design standards. It has narrow shoulders and will not meet future traffic demand. It is also not designed to accommodate pedestrians and bicyclists. The Colorado River Bridge Study will help UDOT determine if the bridge needs to be widened, rehabilitated, or demolished and replaced.

The Colorado River Bridge is located on US-191 between two active UDOT projects. UDOT is currently widening the highway north of the bridge through Moab Canyon to four lanes. In September 2004, UDOT also began the design phase for reconstructing Moab's Main Street south of the bridge. This study looks at the 3-mile stretch between these two projects, from 400 North in Moab to SR-279 (Potash Road), to identify if additional improvements are required to provide continuity between these four-lane segments. In addition to the Colorado River Bridge, the Lower Courthouse Wash Bridge would require widening to provide continuity throughout the corridor.

1.4 Organization of Report

The remainder of this report is organized as described below.

Chapter 2 presents the public involvement activities conducted during the study.

Chapter 3 presents the findings of the traffic study and development of roadway cross-sections.

Chapter 4 presents the geotechnical investigation and recommendations.

Chapter 5 presents the scour investigation and recommendations.

Chapter 6 presents the river crossing locations that were investigated.

Chapter 7 presents the feasible horizontal and vertical alignments.

Chapter 8 presents the conceptual bridge alternatives and the issues involved with each alternative.

Chapter 9 presents the environmental issues associated with the proposed river crossing.

Chapter 10 presents the recommendations for future actions based on the findings of this study.

2.0 AGENCY AND PUBLIC SCOPING

2.1 Agency Scoping

UDOT invited agencies with interests in the project area to participate in the scoping process. Agency representatives were asked to help identify issues in the corridor that needed further review in the environmental study process. An agency scoping meeting was held on March 3, 2004, to solicit agency comments regarding the project. There were 15 attendees at the agency scoping meeting including project team members. Additional information pertaining to the scoping meeting is described in detail in the *Colorado River Bridge Study Scoping Summary Report* prepared by HDR Inc.

Below is a brief summary of the comments received from agency representatives at the agency scoping meeting.

1. **Right-of-Way and Arches National Park.** UDOT will need to obtain easements from the National Park Service for any land needed for the project.
2. **Easement from Utah Division of Forestry, Fire, and State Lands.** An easement will be needed for impacts to sovereign lands. The sovereign lands would be associated with the Colorado River.
3. **Cultural Resources.** There are cultural resources in the area: an old wagon road, a prehistoric rock art panel at Lower Courthouse Wash, and dinosaur tracks near Lower Courthouse Wash. The U.S. Department of Energy conducted an archaeological search on a large area near the Colorado River Bridge project for the purposes of assessing a route for the Moab mill tailings site.
4. **Gateway Plan.** The City of Moab and Grand County have developed a Gateway Plan that calls for a boulevard entry, landscaping, and bicycle lanes for the US-191 entrance into Moab. UDOT's alternatives should be consistent with this plan.

5. **Lions Park.** Grand County is planning improvements to Lions Park, located on the north and south sides of the river. Utah State University designed the improvements. Lions Park might also be used as a parking/staging area for bicyclists in the future.
6. **Water Rights Permit.** UDOT or its contractor will need to obtain a water rights permit if the project requires any water from the river. A permit from the U.S. Fish and Wildlife Service (USFWS) will also be required if there are threatened or endangered species in the river.
7. **General Permit 404 for Stream Alteration.** A stream alteration permit will be required for any modifications to the river.
8. **Stream Alteration Permit for Lower Courthouse Wash.** Modifying Lower Courthouse Wash could also require a stream alteration permit since the wash is a riparian environment.
9. **Bighorn Sheep.** There are desert bighorn sheep in the project area.
10. **Traffic Survey.** The National Park Service requested a copy of the results of the traffic study.
11. **Parking and Access at Lower Courthouse Wash.** There is hiking access at Lower Courthouse Wash to the rock art panel and the Lower Courthouse Wash trailhead. This parking area might need to be expanded to accommodate hikers and to serve as a staging area for bicyclists. This area is outside the limits of Arches National Park.
12. **BLM Kiosk.** The Bureau of Land Management (BLM) is planning a short-term parking area with an information kiosk at the intersection of US-191and SR 279 (Potash Road). There is a small parcel of public land on this corner.
13. **Bridge Location.** The attending agencies did not raise any "fatal flaw" concerns with the bridge location. The National Park Service asked to place the new bridge downstream of the current one, away from National Park Service property.

2.2 Tribal Consultation

The Federal Highway Administration (FHWA) sent letters to the Native American tribes represented in the area on February 25, 2004, to request their suggestions and concerns regarding the Colorado River Bridge. A copy of the letter and the tribal mailing list is included in the project's administrative record. UDOT also sent a copy of the Class I Cultural Resource Study to the Hopi Tribe. The Hopi Tribe requested a copy of the completed cultural resource report.

2.3 Public Scoping

UDOT held a public scoping meeting on March 3, 2004, at the Grand County Senior Citizen Center at 100 South 450 East in Moab. The meeting was held in an open-house, town-meeting format and a project workshop followed. For the workshop portion of the meeting, the participants broke into small groups facilitated by project team members. A total of 7 people from the public attended the town meeting portion of the scoping meeting. A total of 23 people participated in the project workshop. The town meeting and project workshop formats and additional information are described in detail in the *Colorado River Bridge Study Scoping Summary Report* prepared by HDR Inc.

Despite the low attendance at the open house, the workshop participants provided comments on several different issues and produced over 126 individual comments regarding various resource areas. Below is a summary of the highest-priority comments.

- **Bridge.** Design a welcoming, aesthetically pleasing bridge because it is the primary entrance into Moab. The design should be non-obtrusive and compatible with the natural surroundings.
- **Bicyclists/Pedestrians.** The project team should provide safe bicycle and pedestrian access throughout the corridor, including across the bridge and to various recreation areas to eliminate the need to cross US-191.
- **Gateway Plan.** UDOT should consider the Gateway Plan (developed by the City of Moab and Grand County) during design, including incorporating plans for developing recreation areas and expanding trail development.
- **Capacity.** The project should include enough capacity on the bridge and in the project area to allow safe travel through the corridor now and into the future.
- **Business Access.** UDOT should ensure that enough lanes are provided for access to businesses and that acceleration lanes are provided to accommodate buses and boat trailers.
- **Courthouse Wash.** Improvements to the bridge at lower Courthouse Wash should be considered in this project.
- **Wildlife.** The project team should address wildlife fencing and crossings to allow wildlife safe access to the river. Consideration needs to be given to threatened and endangered species in the area.
- **Drainage.** Drainage improvements on the north end of Moab should be incorporated to protect water quality in the area.
- **Intersections.** The project team should consider intersection improvements throughout the project area to accommodate projected growth.
- **Construction.** Construction should be planned to minimize impacts and accommodate traffic, especially during the tourist season. UDOT needs to minimize construction impacts such as light, dust, and noise impacts.
- **Recreation.** The project should provide adequate and safe recreation access under the bridge.
- **Traffic Calming.** Traffic-calming measures to slow vehicles and reduce traffic noise should be incorporated into the project.
- **Tailings Site.** The project team should consider the issues regarding the uranium-tailings site in the project area.
- **Cultural Properties.** The project team should work to protect natural, cultural, and historic properties in the project area.

A Scoping Summary Report detailing the public and agency scoping activities and summarizing the comments received during the scoping period (February 19, 2004 through April 2, 2004) was released to the public in June 2004. It was available for public review at the Grand County Library and the Moab and Grand County Offices. A newsletter announcing the release of the Scoping Summary Report and summarizing the comments from the scoping period was mailed to the nearly 350 members of the project mailing list on June 4, 2004. A copy of this newsletter is included in the project's administrative record. A public summary meeting and presentations to the Moab City Council and Grand County Council are planned for early fall of 2004.

2.4 Additional Public Involvement

2.4.1 Stakeholder Meetings

Individual meetings were held with the following stakeholder groups to identify suggestions, comments and concerns to examine further in the Colorado River Bridge Study:

- Bureau of Land Management – January 15, 2004
- City of Moab – January 16, 2004
- Grand County – January 16, 2004

- National Park Service – January 28, 2004

Minutes from these meetings have been included in the project's administrative record.

2.4.2 Origin and Destination Survey

During the public scoping period, the project team also conducted the roadway, origin and destination survey. The project team distributed "project issues" flyers to 1,000 motorists who stopped to participate in the survey. The surveys and flyers were distributed to a random sample of vehicles that included trucks, recreational vehicles, local traffic, and tourist-related traffic that crossed the Colorado River Bridge between March 25 and March 27, 2004. The analysis and results of the survey are discussed in detail in Appendix A.

3.0 TRAFFIC PLANNING AND CROSS-SECTION DEVELOPMENT

InterPlan Co. prepared the *Colorado River Bridge, US-191 Traffic Report* for this study. This report, attached as Appendix A, includes traffic analysis results, traffic survey findings, and recommended roadway cross-sections.

4.0 GEOTECHNICAL INVESTIGATION AND RECOMMENDATIONS

RB&G Engineering conducted a literature review of previous geotechnical studies performed in the vicinity of the bridge site and provided recommendations relating to anticipated foundation types and bearing capacities for the proposed bridge.

4.1 Geology

The geologic setting of the region is characterized by great elongated depressions formed by removal of subterranean salt masses. The depressions are mostly elongated oval valleys trending northwesterly with high surrounding walls (Stokes, Geology of Utah, 1987). Structural features include the Moab Anticline, which has been mapped trending in a northwesterly direction through Moab Valley, and the Courthouse Syncline, which parallels the anticline to the east. Bedrock in the area consists predominately of Navajo Sandstone (Upper Triassic) with underlying shale, siltstone, and conglomerate of the Hermosa Formation (Middle Pennsylvanian). Surficial soils consist predominately of alluvial fan gravel deposits.

4.1.1 Earthquake and Seismic Considerations

The area is considered to have low seismic risk and is in American Association of State Highway and Transportation Officials (AASHTO) Seismic Performance Zone 1. It is anticipated that the site will be defined as Site Class C according to the 2003 International Building Code (AASHTO Soil Profile Type I). The site is located at latitude 38.6043° North and longitude 109.5777° West. Table 1 shows the probabilistic peak ground acceleration (PGA) values obtained from the U.S. Geological Survey (USGS) Web site.

Table 1. Probabilistic Ground Motion Values in %g

	10% PE in 50 yr	2% PE in 50 yr
PGA	4.12	9.91
0.2 sec SA	9.26	21.25
1.0 sec SA	2.79	6.41

4.2 Existing Bridge

The existing bridge structure (No. C-285) is an eight-span bridge approximately 1000 ft long and 29 ft wide that carries US-191 over the Colorado River at milepost 128.62 on the north side of Moab, Utah. Table 2 shows the elevations associated with the bridge.

Table 2. Existing Bridge Elevation

Location	Elevation (ft)[a]
Top of rail on bridge	3,985.6
Roadway on bridge at pier 5	3,982.0
Water level at bridge, October 1999	3,951.3
Water level at bridge, October 1994	3,951.1

[a] Elevations are based on as-built plans.

The bridge plans were prepared by Woodruff & Sampson Engineers in 1953, and a review of the plans revealed the following information.

Existing Geological Data

The Woodruff & Sampson plans show geologic sections based on surveys by Mulville (1934) and by Newell (1951) near the bridge alignment. A set of 18 borings dated 1953 is also included on the existing bridge plans. Table 3 provides a generalized summary of these surveys and borings.

Table 3. Geologic Section Surveys and Boring Data

Newell (1951), Mulville (1934) Surveys	
Elevation	**Material Encountered**
3963	Silt and Sand with some Gravel, layer is only about 2' thick at the deepest part of the river.
3945	Gravel with Sand and some Clay, some Boulders, layer ranges from about 7 to 15 feet thick
3936	Red, Blue, Yellow Clay and Shale layer from 0 to about 14 feet thick
3928	Brown, Gray, White, and Red Sandstone from 3 to 17' thick, some Blue Shale and Red Clay layers
3920	Blue and Red Clay with layers of Conglomerate and Sandstone in some borings
3895	

Source: Based on as-built plans.

1953 Borings	
Elevation	**Material Encountered**
3962	Sand and Silt
3945	Gravel with coarse Sand, layer ranges from about 5 to 19 feet thick
3933	Predominantly Red, Brown, Yellow, Blue, Gray, Purple Sandstone with some Shale and Siltstone, some Clay layers, Conglomerate layers in some holes, profile varies significantly from one boring to the next.
3895	

Source: Based on as-built plans.

Foundation for Existing Bridge

The foundation for the existing structure includes two abutments and seven hammer-head type piers supported on piles as summarized in Table 4.

Table 4. Existing Bridge Foundation Features

Station (SE to NW)	Bridge Feature	Piles	Pile Length (ft)	Pile Tip Elevation (ft)	Bearing Material
188 + 30.00	Abut. 1	8	28	3932.8	Sandstone / conglomerate
190 + 04.63	Pier 2	20	17	3924.8	Sandstone / conglomerate
191 + 39.25	Pier 3	20	17	3925.0	Clay / conglomerate
191 + 75.63	Pier 4	20	31	3911.2	Shale with clay layers
193 + 90.00	Pier 5	18	14	3928.6	Sandstone / conglomerate
194 + 04.37	Pier 6	20	17	3925.2	Sandstone
196 + 40.75	Pier 7	20	17	3925.0	Sandstone (soft)
197 + 76.38	Pier 8	20	15	3926.8	Sandstone (soft)
198 + 90.00	Abut. 9	8	33	3927.8	Sandstone (soft) / clay

Each abutment has two footings approximately 9.1 ft by 7.3 ft by 3.0 ft high. Each abutment footing is supported on four piles.

The footings for piers 3 and 7 are 24 ft in diameter with one 21-ft diameter ring of 20 evenly spaced piles.

The footings for piers 2, 4, 6, and 8 are 22 ft in diameter with one 18.6-ft-diameter ring of 14 piles. An inner ring 13.2 ft in diameter contains 6 piles. Piles are generally more concentrated on the upstream and downstream sides of the footings, creating a stronger axis parallel to the river flow and transverse to the bridge alignment.

The footing for pier 5 is similar to the footings for the even-numbered piers, but contains only 4 piles in the inner ring.

Piles in drawings appear to be about 12 in. in diameter and are specified as "other than timber."

Underwater inspections have occurred about every 5 years since at least 1989. Column footings are exposed for piers 5, 6, 7, and 8. Inspectors have discovered partial seal exposure, spalled and cracked concrete, some exposed and corroded reinforcing steel, and some scour around the footings. Maximum water depth at the bridge ranged from about 11 to 15 ft around pier 6 in October 1994 and October 1999.

4.3 Scour Potential

The 1953 Woodruff & Sampson 'As Constructed' drawings show that bedrock in the river channel is overlain by 8 to 30 ft of sand, silt, and gravel. These predominantly granular soils should be considered as moderately to highly erodible. It is anticipated that scour will be limited to these upper layers of alluvium. The underlying bedrock is described as soft sandstone with some shale and conglomerate layers. This rock may be subject to scour during extreme events if the overlying alluvium is sufficiently eroded.

It appears from the 1953 drawings that the pier foundations for the original construction were located 6 to 10 ft below the river bottom. The underwater bridge inspection reports for the existing structure indicate that scour is a concern at this site. Han-Padron Associates (2000) reported maximum degradation of 3 to 5 ft due to scour between 1994 and 1999. The inspection report states:

> Overall, the bridge substructure is in fair condition due to the extent of the deterioration (cracking & spalling) of the substructure units. The waterway is in satisfactory condition due to an increase in localized scour around the piers and some general scour across the channel...
>
> ...There does appear to be general scour and an increase in localized scour at this bridge site.

No remedial actions were recommended, and there was no indication that the pier foundations were unstable. However, the inspection report recommended that inspections should be performed on a regular basis.

Local scour at piers is a function of bed material characteristics, bed configuration, flow characteristics, fluid properties, and the geometry of the pier and footing. The scour equation provided in HEC-18 is considered to be conservative for scour analysis. The equation allows for correction factors for bedding conditions, angle of attack, pier nose shape, and armoring. Chapter 6 of the HEC-18 document states that, as a "rule of thumb," the maximum scour depth for round nose piers aligned with the flow is 2.4 times the pier width for Froude numbers less than or equal to 0.8 and 3 times the pier width for Froude numbers greater than 0.8.

For the large-diameter piers used for the existing bridge, scour countermeasures such as armoring would have decreased the present scour concern.

4.4 Foundation Recommendations

Based on the information summarized above, it is recommended that deep foundations extending into competent bedrock should be required for the proposed bridge. The existing roadway is at about elevation 3,982 ft with the abutment footings at about elevation 3,961 ft and the piers at about elevation 3,942 ft. Piles supporting the foundations are extended through the alluvium between 15 and 33 ft below the foundation level (average 21 ft) with the pile tips bearing predominantly on soft sandstone. The pile tip elevation ranged from elevation 3,911 ft to 3,933 ft (average elevation 3,925 ft). Pile capacities were not shown on the plans. (Elevations are based on as-built plans.)

There appear to be interbedded layers of siltstone, shale, and conglomerate with the soft sandstone throughout the profile and occasional soft clay seams. The allowable design capacity should be based on the weakest layer within 3 to 5 pile/shaft diameters of the toe elevation. Final design should include test borings at each pier to identify the bedrock profile. Bearing within 5 diameters of soft clay seams should be avoided.

Due to the variation in alluvial thickness and bedrock profiles at the existing structure, it is recommended that site-specific subsurface investigation should be performed at each pier location during final design to adequately define the subsurface characteristics for design analysis.

Driven piles will likely be the most efficient type of deep foundation for the structure. Acceptable pile types include steel 'H' sections and closed-end concrete-filled pipe piles. The 1953 'As Constructed' drawings show that piles were driven approximately 10 ft into the bedrock, which consists predominantly of soft sandstone. Details of the pile materials or pile-driving system are not known; however, we anticipate that similar depths into the bedrock will be achievable. Drilled shafts may also be considered as a potential foundation type. Based on the bedrock description shown on the 1953 geologic section, the bedrock should be able to be efficiently drilled and that socketing shafts 10 ft into the rock can be performed using conventional drilling procedures. Some difficulty can be expected when drilling in conglomerate layers, which will likely result in increased bit usage. Foundation installation in the flowing river will require special procedures and equipment, and constructability issues should be carefully considered in determining the most efficient foundation system.

Based on the bedrock profile, it is recommended that an ultimate (unfactored) end bearing capacity in the order of 600 tons per square foot be used for preliminary design of deep foundations. According to the *2002 AASHTO Interim LRFD Bridge Design Specifications*, a geotechnical resistance factor of $0.50\lambda_v$ should be used for the Strength Limit State. The factor λ_v should range from 0.8 to 1.0, depending on the extent of installation control and capacity verification methods. A geotechnical resistance factor of 1.0 is recommended for the Service Limit State. For driven piles, a further reduction factor of 0.875 should be considered under the assumption that moderate driving difficulty will be encountered. It should be noted that the structural strength of foundation elements may be more critical than the geotechnical resistance parameters listed above.

The plans for the existing structure state that Type II cement was to be used for all concrete. A review of the underwater inspection report completed by Han-Padron Associates, dated January 2000, did not identify significant corrosion problems with the foundation concrete which would be associated with sulfate attack. It is recommended that Type II cement be used for concrete associated with the proposed structure.

5.0 SCOUR INVESTIGATION AND RECOMMENDATIONS

A scour investigation was conducted to provide information for the feasibility study about the scour potential of the Colorado River Bridge and to provide recommendations to avoid or minimize scour-related problems in the future.

5.1 Previous Studies

UDOT and others have been observing this bridge because of its classification as structurally obsolete and because of the projected increase in traffic volumes. Previous studies and reports are noted below.

The UDOT Hydraulic Division prepared the *SR 191 over Colorado River Scour Project Design Study Report* in September 2002. This report includes underwater bridge inspections, special provisions needed for the scour countermeasure work, a list of work to be completed, pertinent environmental correspondence, peak flow calculations for the Colorado River through this section, HEC-RAS scour depth calculations, channel cross-sections, and project photos. The findings of this report indicated that the existing bridge substructure is considered scour-critical.

Michael Baker Jr. Inc. prepared the *Bridge Concept Report for Bridge Preservation Project* in April 2001. This report presents an overview of the scope of work and cost for scour countermeasure and mitigation treatments.

The U.S. Geological Survey (T.A. Kenney) completed the *Hydraulic and Geomorphic Monitoring of Experimental Bridge Scour Mitigation at Selected Bridges in Utah* in January 2004. This draft report details the bridge scour countermeasures that were implemented in June 2003 at the Colorado River Bridge. The report discusses techniques that the USGS is employing to monitor and assess the performance of these scour countermeasures including the use of an acoustic Doppler current profiler interfaced with a differential global positioning system.

The conclusions and recommendations presented in this study were based on site visits and data from these previously completed studies.

5.2 Scour Countermeasures

The scour countermeasures used at the Colorado River Bridge consisted of fiber wrap around the piers and bents, and placement of A-Jacks armor units at three scour-susceptible areas of the bridge (piers 5, 6, and 7). See Figure 1. The single A-Jacks structures were banded together to form modules and were then placed in a matrix on the streambed. Figure 2 shows the design for the A-Jacks deployment. This design is unique, and there have not been many (if any) long-term case studies for this type of deployment into steep, mobile gravel bed river environments. Figure 3 and Figure 4 show the installation of the fiber wrap.

Figure 1. A-Jacks

Figure 2. Schematic Plan for Installation of A-Jacks Scour Countermeasure

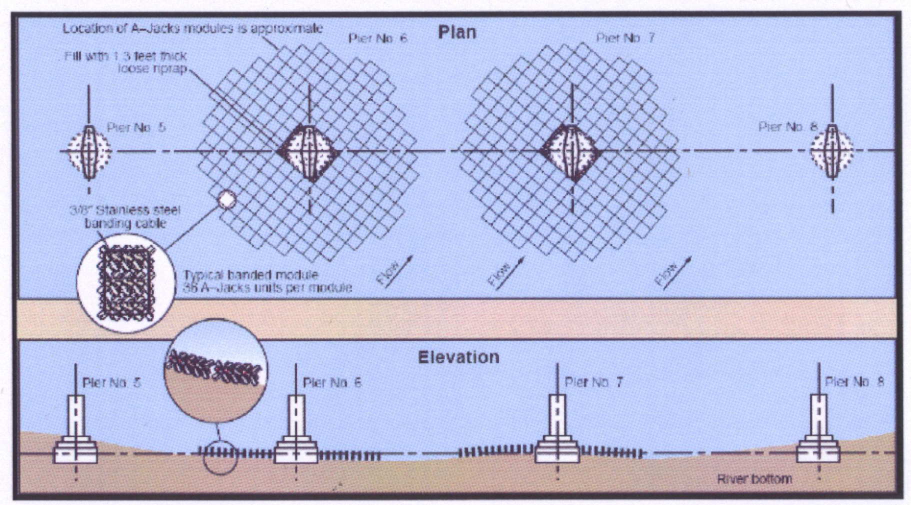


Figure 3. Installation of the Fiber Wrap (Looking North)

Figure 4. Installation of Fiber Wrap (Looking North)

5.3 Scour Depth

The previously mentioned UDOT Central Hydraulics design report included flow calculations, a scour analysis, and various design calculations. UDOT performed a Log-Pearson statistical analysis with HYDRO software version 6.1, using stream flow data from the USGS gage station 09180500 on the Colorado River near Cisco, Utah. UDOT then performed scour depth calculations using the hydraulics predicted by HEC-RAS and the FHWA HEC #18 methodologies included in the software. The pier scour depth calculated was 39.24 ft, corresponding to a 100-year flow. Armortec was provided with this predicted scour depth to design the A-Jacks layout that was employed at the Colorado River Bridge.

The peak gage height is 20.70 ft measured from the gage datum of 4,090 ft on May 27, 1984, corresponding to a discharge of 70,300 cfs. The extreme discharge outside the period of record is an estimated discharge from Fruita, Colorado, of 125,000 cfs. UDOT calculated the flood peak flow discharges for the 2, 5, 10, 25, 50, 100 and 500-year flow events. These values are shown in Table 5. HEC-RAS output was not included in the UDOT report, but conversations with UDOT and the USGS indicate that the 100-year water surface approaches the low chord of the existing structure.

Table 5. Flood Peak Discharges

Return Event	Discharge (cfs)
Q_2	32,964
Q_5	49,158
Q_{10}	59,323
Q_{25}	71,399
Q_{50}	79,854
Q_{100}	87,848
Q_{500}	105,069

Source: UDOT September 4, 2002

Figure 5 shows the water level on a site visit.

Figure 5. Water Level on a Subsequent Site Visit, May 11, 2004 (Looking South)

5.4 Discussion and Recommendations

High flow events in the Colorado River mobilize a considerable amount of abrasive sediment. Over the years, these abrasive high flow events have caused damage to structural elements of several piers. In addition, general and local scour have exposed portions of existing pier foundations. The extreme flow conditions, site geology, and debris potential amplify the importance of carefully evaluating bridge foundation alternatives to minimize hydraulic and scour impacts to the structure during the design life of the bridge. The following recommendations are made to ensure that the evaluation of hydraulic factors are properly addressed when selecting bridge foundation alternatives.

Regardless of the option chosen to address the existing substandard Colorado River Bridge (widening, rehabilitation, or replacement), scour-related issues need to be addressed in the initial stages of design. The scour countermeasures installed in June 2003 will be closely monitored by UDOT and USGS for at least 2 years as part of a cooperative research agreement. This information should be useful in providing insight into the effectiveness of the installed countermeasures. However, this may not be enough time to fully evaluate their long-term effectiveness.

The HEC-RAS models used in the referenced past studies should be obtained and reviewed. Predicted scour computations for the existing structure should be reviewed and scour depths (general, local, and abutment) should be predicted for the proposed bridge foundations for use in evaluating potential alternatives.

Currently, three bridge foundation alternatives are under consideration. All three pier alternatives consist of 4 to 5 columnar supports, per pier, exposed to Colorado River flows. Circular columns are typically less susceptible to debris collection, and the proposed spacing of the columns (18 ft minimum) should be sufficient to allow the majority of debris to pass through piers as necessary without a "bar screen" collection effect that can occur with closely spaced supports. The multiple columns proposed for each pier will be more sensitive than single-column piers to skewed flow approaches, and proper orientation of the piers to predominate flow patterns should be addressed. Finally, pier options A, B, and C should be evaluated using the complex pier scour computation methodologies from HEC-18 to account for the variance in the proposed pier shape and width relative to depth.

Before the bridge foundation is designed, a geotechnical investigation should be completed. The FHWA Technical Advisory T5140.23, Evaluating Scour at Bridges, states:

> The geotechnical analysis of bridge foundations (for new bridges) should be performed on the basis that all stream bed material in the scour prism above the total scour line for the design flood (for scour) has been removed and is not available for bearing or lateral support. In addition, the ratio of ultimate to applied loads should be greater than 1.0 for conditions of scour for the superflood (flows exceeding the 100-year flood).

A critical component of the geotechnical investigation should be determining the erodibility of underlying strata, specifically the sandstone layer approximately 10 ft below the existing mudline. Depending on the competence and resistance to erosion of this layer, local scour depths predicted to occur during the design life of the bridge may be reduced and cost savings realized in the foundation design.

6.0 RIVER CROSSINGS INVESTIGATED

The suitability of the current crossing location and other locations within the confines of the mountain bluffs on each side of the Spanish Valley were investigated. Two river crossing locations were identified for investigation based on the location of the existing roads, wetlands, the wildlife preserve, Department of Energy sites, and the geological features of the valley. The first location is that of the existing bridge. The second location is southwest of the existing crossing along the western bluffs. A crossing at this second location, connecting Kane Creek Boulevard to SR 279 (Potash Road), would require improvements to these roadways. Improvements would include widening the roadway, constructing intersections and/or interchanges, acquiring new right-of-way, and constructing a new bridge. The cost of these improvements would be more than the cost of constructing a new bridge at the existing crossing. Due to the additional environmental concerns, topography, and the increased cost of relocating the crossing, it is recommended that a crossing remain at the existing location. This will not preclude a bypass crossing from being constructed in the future.

7.0 HORIZONTAL AND VERTICAL ALIGNMENTS

The study team developed alignment alternatives to minimize environmental and property impacts. The horizontal alignment was restricted on the east and north by Arches National Park. To minimize impacts to the park, the study team did not consider extending the east edge of the proposed roadway/bridge beyond the east edge of the existing bridge. The vertical alignment developed by the study team was required to meet the regulatory controls set by the U.S. Coast Guard (USCG) and U.S. Army Corps of Engineers (USACE). The bridge is located in and over the Colorado River, which is designated as a navigable waterway and is therefore subject to the regulatory requirements for such waterways. The existing vertical and horizontal clearances of the channel must be maintained. These clearances are not specifically defined for this particular stretch of the Colorado River, but are determined on a case-by-case basis by USCG and USACE. The necessary permits will need to be obtained from the appropriate agencies and regulatory bodies before construction begins.

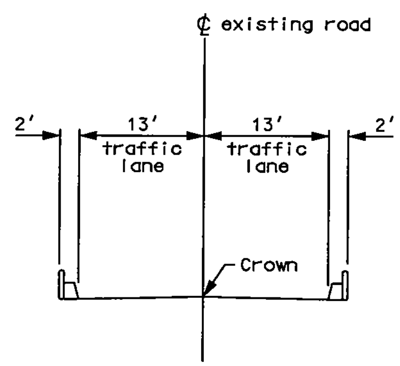
7.1 Description of Alternatives

Preliminary typical roadway sections are shown in Figures 6 and 7 on pages 10 and 11. The shoulder widths shown on these figures may be modified based on approved design exceptions received prior to final design of the roadway.

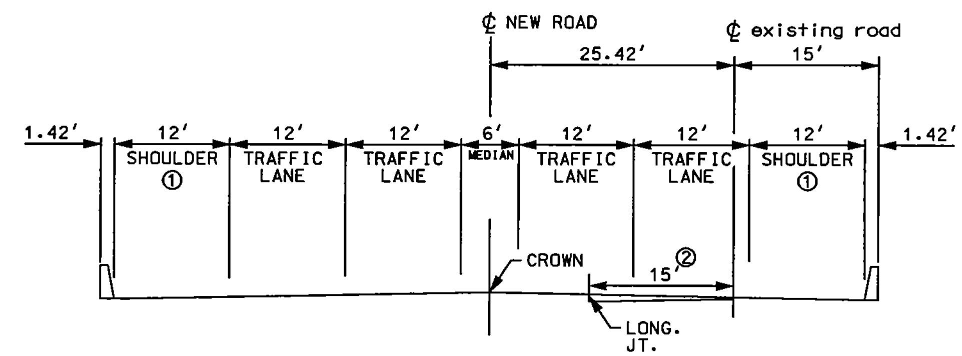
- **Alternative 1 – No Build/No Action.** The existing structure would remain in service. No new environmental or property impacts would result from this alternative. The existing alignment would remain the same. See Figure 6.
- **Alternative 2 – Widen Existing Bridge.** This alternative includes providing additional roadway capacity and full width shoulders by widening the existing bridge. The bridge widening would consist of constructing a new structure adjacent to the existing structure and joining the bridge decks. See Figure 6.
- **Alternative 3 – Construct a New Southbound Bridge.** This alternative consists of constructing a new bridge west of the existing structure that would carry southbound traffic. The existing structure would carry northbound traffic. The new southbound bridge would include full width shoulders. See Figure 6.
- **Alternative 4 – Construct a New Bridge with Pedestrian/Bicycle Facility on Existing Bridge.** This alternative consists of constructing a new bridge west of the existing bridge. The new bridge would carry northbound and southbound traffic over the Colorado River. After new bridge is built, the existing structure would function as a bicycle/pedestrian bridge. See Figure 7.
- **Alternative 5 – Construct a New Bridge (phased).** Under this alternative, half of the new bridge would be constructed west of the existing bridge during the first phase of construction. After the first phase is completed, traffic would use the new bridge while the old bridge is removed and the second phase of the new bridge is constructed. The phased construction minimizes new right-of-way required and impacts at the bridge location. The new bridge would carry northbound and southbound traffic over the Colorado River. See Figure 7.
- **Alternative 6 – Construct a New Bridge on an Alternate Alignment.** Under this alternative, a new structure would be constructed on a new alignment downstream of the existing bridge. One possible option would be constructing an interchange at Potash Road. This would require acquiring additional right-of-way, widening and improving Potash Road, and an increased cost for building a new roadway. The existing bridge would be demolished and would not be replaced. See Figure 7.
- **Alternative 7 – Construct a New Bridge (non-phased).** This alternative would consist of constructing a new structure downstream of the existing bridge. The new bridge would carry northbound and southbound traffic over the Colorado River. The existing structure would be removed after construction of the new bridge. See Figure 7.

FIGURE 6

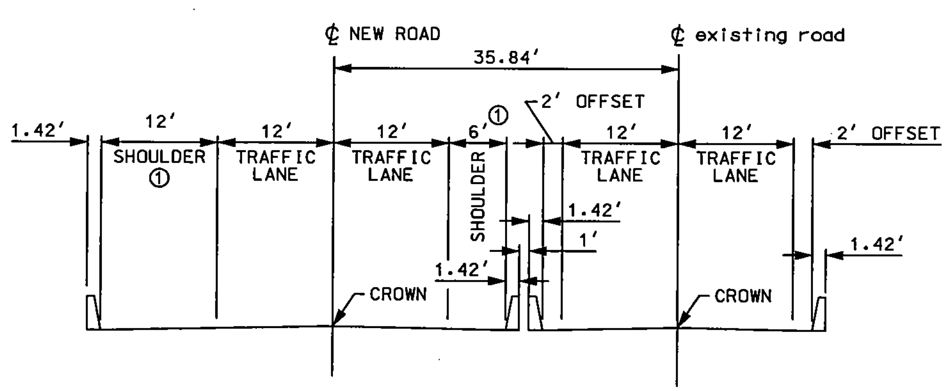
ALTERNATIVE 1



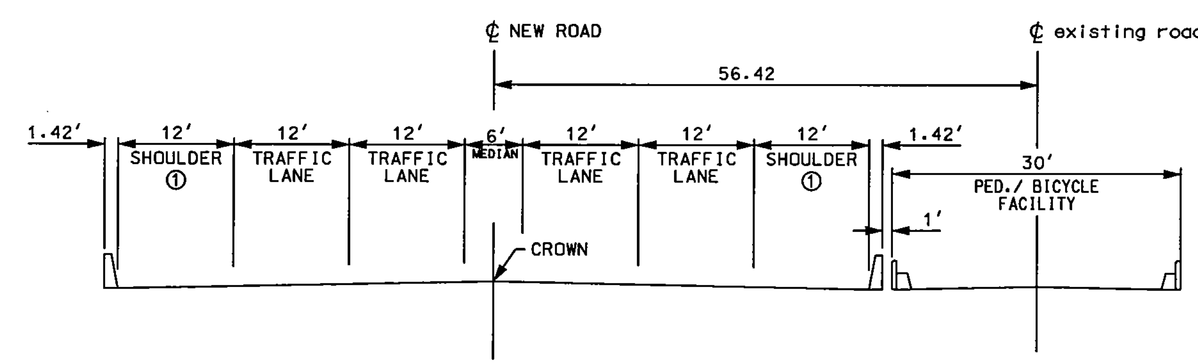
ALTERNATIVE 2



ALTERNATIVE 3



ALTERNATIVE 4



① SHOULDER WIDTH INCLUDES 2' BARRIER OFFSET.
② EXISTING STRUCTURE TO BE OVERLAYED TO ATTAIN PROPER CROSS SLOPE.

PRELIMINARY - NOT FOR CONSTRUCTION

UTAH DEPARTMENT OF TRANSPORTATION
REGION 4, RICHFIELD, UTAH
HDR ENGINEERING, INC.

US-191 OVER COLORADO RIVER
COLORADO RIVER BRIDGE STUDY
TYPICAL ROADWAY SECTIONS

PROJECT NUMBER BRF-0191(23)128

DESIGN / CHECK / DRAWN / CHECK / QUANT. / CHECK
APPROVAL RECOMM. / DATE / SENIOR DESIGN ENGR.
APPROVED FOR USE BY UDOT / DATE / UDOT BRIDGE ENGR.

REVISIONS: NO. / DATE / BY / REMARKS

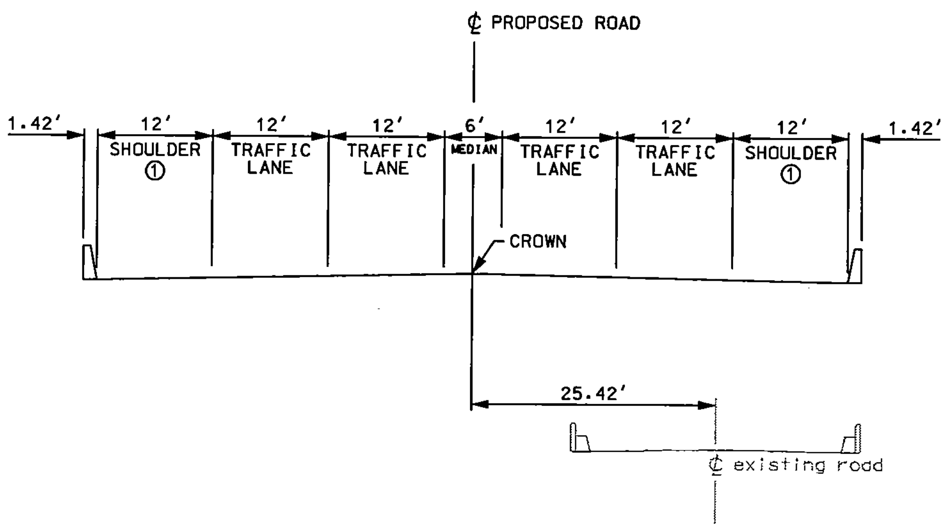
GRAND
COUNTY

DRG. NO.

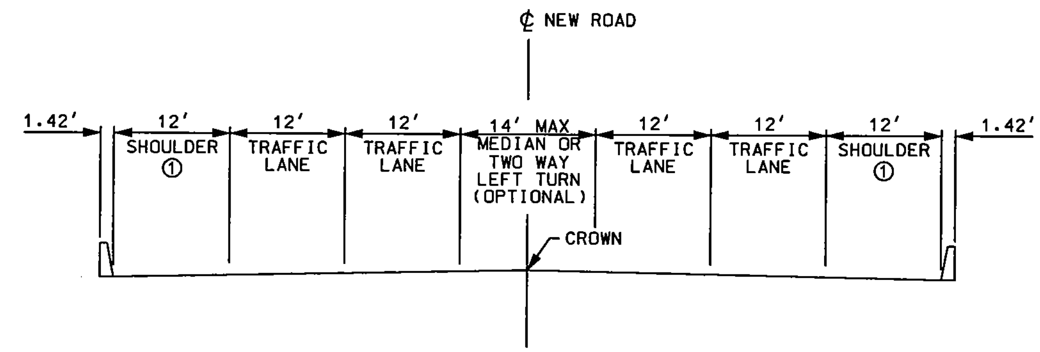
SHT. 10

FIGURE 7

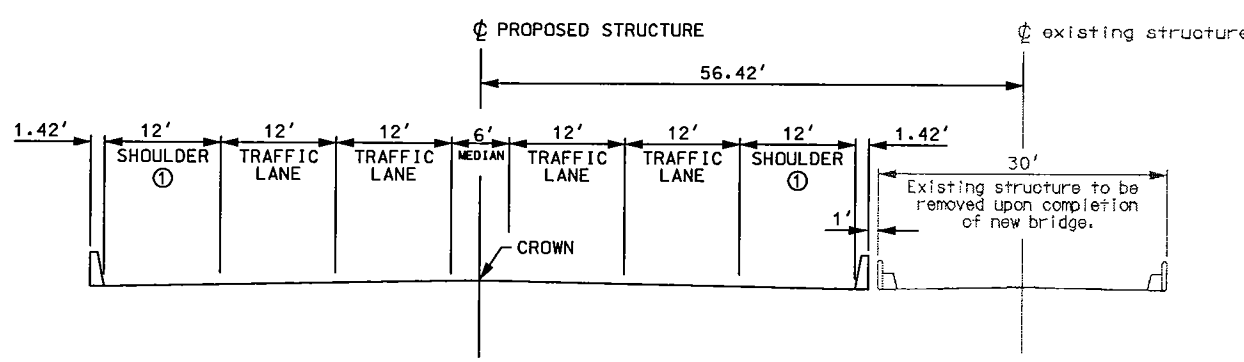
ALTERNATIVE 5



ALTERNATIVE 6



ALTERNATIVE 7



① SHOULDER WIDTH INCLUDES 2' BARRIER OFFSET.

PRELIMINARY - NOT FOR CONSTRUCTION

REVISIONS

NO.	DATE	BY	REMARKS

UTAH DEPARTMENT OF TRANSPORTATION
REGION 4, RICHFIELD, UTAH
HDR ENGINEERING, INC.

DESIGN ____ CHECK ____
DRAWN ____ CHECK ____
QUANT. ____ CHECK ____

APPROVAL RECOMM. ____ DATE ____ SENIOR DESIGN ENGR.
APPROVED FOR USE BY UDOT ____ DATE ____ UDOT BRIDGE ENGR.

US-191 OVER COLORADO RIVER
COLORADO RIVER BRIDGE STUDY
TYPICAL ROADWAY SECTIONS

PROJECT NUMBER BRF-0191(23)128

GRAND
COUNTY

DRG. NO.

SHT. 11

11/09/2004 05:20:04 PM \\SLC-BDC\projdocs\Colorado River Bridge Study\3418_04\Sheet_Files\Roadway_Design\3418_Figure 7.dgn

...\3418_Figure 7.dgn 11/09/2004 05:20:04 PM PrinterBW.plt

8.0 BRIDGE FEASIBILITY ALTERNATIVES

8.1 Bridge Alternatives - Conceptual Designs

This section discusses possible alternatives based on the roadway typical sections and horizontal alignments identified in Chapter 7. Preliminary typical roadway sections are shown in Figures 6 and 7 on pages 10 and 11. Two bridge types are compared for the purposes of this study: a continuous precast prestressed concrete girder bridge and a continuous steel plate girder bridge. The new structure would be designed using AASHTO Load and Resistance Factor Design (LRFD) Bridge Design Specifications.

The number of deck joints should be minimized, but will likely be required at the abutments to accommodate thermal forces. Minimizing the number of deck joints decreases the maintenance required to ensure that the joints function as intended. Water collected on the bridge deck should be prevented from draining directly into the river using an appropriate drainage system. If deck drains are used the collected water would be conveyed to the abutments and discharged. A waterproofing membrane and overlay could also be used. The membrane is placed between the concrete deck and overlay, which is place over the bridge joints. Water is then collected in the roadway drainage system when it leaves the bridge.

The following four different configurations were evaluated based on practical girder sizes, spacing, and span lengths.

- **Configuration 1.** A 7-span bridge with precast prestressed AASHTO Type VI girders
- **Configuration 2.** A 4-span bridge with steel plate girders
- **Configuration 3.** A 5-span bridge with steel plate girders
- **Configuration 4.** A 6-span bridge with steel plate girders

Concrete Girders

Precast prestressed concrete girders are generally economical and are commonly used for highway bridges. They are often used for spans under 150 ft. Their main disadvantage is the limited availability of different girder sections. Precast prestressed girders (most likely AASHTO Type VI) that are capable of spans up to 145 ft are required. This option would require a 7-span (143'/143'/143'/143'/143'/143'/143') system made continuous for live load. For these span lengths, center-to-center lateral spacing of these girders ranges from 6 ft to 7 ft.

Steel Plate Girders

Another commonly used bridge type for highway bridges is built-up steel plate girders. For this crossing, 4, 5, or 6 spans are practical. The depth of the girder can be estimated from span-to-depth ratios. Work required in the river and other environmentally sensitive areas is reduced by using fewer spans, which decreases the number of piers. If a 4-span (220'/280'/280'/220') system were used, only three piers would be required. If a 5-span (177.5'/215'/215'/215'/177.5') system were used, four piers would be required. If a 6-span (140'/180'/180'/180'/180'/140') system were used, five piers would be required. Steel girders can generally be economically spaced center-to-center from 10 ft to 13 ft. Recently, steel prices have increased significantly and price fluctuations are expected to continue. Girders are assumed to be grade 50 steel. Hybrid girders with high performance steel grade 70 steel for flanges in moment regions could also be used.

Conventional steel or weathering steel could be used. Conventional steels require an application of paint and continued maintenance throughout the life of the bridge to maintain the paint system. Weathering steel has a natural oxide coating. Minor damage to weathering steel heals itself which reduces maintenance. Weathering steel can be used in many atmospheric environments and is available in strengths of 50 ksi and 70 ksi. Significant first cost and life cycle cost savings can be provide because little or no painting is required. Appropriate precautions should be taken when using weathering steel to during fabrication, handling, and construction to minimize cleaning required after construction and to minimize staining of the concrete substructures.

8.1.1 Alternative 1 – No Build/No Action

Alternative 1 is the "no build/no action" alternative and would leave the existing structure in service. The bridge will require maintenance and rehabilitation to maintain the current level of service. The capacity of the crossing does not increase and the safety features, shoulder, and traffic railing are not upgraded to current design standards. In addition, leaving the bridge "as is" does not provide continuity between the roadway north and south of the bridge, which is in the process of being widened to four lanes.

The existing bridge is classified as functionally obsolete due to its substandard shoulder widths and bridge railing. The current sufficiency rating (S.R.) of the bridge is 47.0, which should qualify the bridge for federal funding. The sufficiency rating is a calculated numeric value used to indicate the sufficiency of a bridge to remain in service. Federal and state agencies use the sufficiency rating to determine the relative sufficiencies of the nation's bridges. In the recent past, eligibility for federal funding with Highway Bridge Replacement and Rehabilitation Program funds has been determined by the following criteria:

S.R. ≤ 80 Eligible for rehabilitation

S.R. < 50 Eligible for replacement

The sufficiency rating is also used by some states as the basis for establishing priority for repair or replacement of bridges—the lower the rating, the higher the priority.

The existing structure is a two-girder bridge, which does not have load path redundancy and as a result is classified as fracture critical. The main girders are the fracture critical members. The bridge was designed for an H20 truck load (1950 AASHTO code) and has inadequate shoulder widths and substandard traffic railings. The substructure has deteriorated substantially as documented by recent inspections. This deterioration has included spalling of concrete at some pier caps and cracking of pier columns, footings, and pile caps. The deterioration has exposed the underlying steel reinforcement in some of the column caps and columns. Channel erosion and scour have also occurred. An underwater inspection conducted on November 21, 2003, by Associated Diving and Marine Contractors documented substantial damage to Pier 6 due to erosion. The condition of the substructure below the mud line including the piles is unknown and cannot easily be inspected. Repair work to mitigate deterioration has included scour prevention measures and the use of fiber-reinforced polymer to repair some of the piers. Additional repairs and maintenance will be required in the future to ensure that this bridge remains safe and functional. Lane restrictions or bridge closures could be required during repair or rehabilitation limiting access to Moab.

The activities required to rehabilitate this bridge include the following:

1. Resurface the bridge deck.
2. Replace deck drains to prevent draining onto girders and into the river.
3. Replace the existing bridge railing with one that meets current safety standards and crash tests.
4. Replace deck joints.

5. Replace girder bearings.
6. Seismically retrofit the bridge to conform to current bridge design specifications.
7. Rehabilitate the floor beams near the expansion joints that have experienced section loss due to corrosion.
8. Rehabilitate the columns and caps of piers 2, 3, and 4.
9. Rehabilitate the foundations beneath the water level.
10. Perform additional underpinning/anchoring of the bridge foundation.
11. Repair the paint system.

It is recommended that the existing bridge be replaced and demolished due to the non-redundant and fracture critical nature of its structural system, substandard safety features, unknown condition of the substructure below the mud line, and future cost of rehabilitation and repair. For these reasons, this alternative was not carried forward for detailed review as a feasible alternative.

8.1.2 Alternative 2 – Widen Existing Bridge

This alternative would provide additional roadway capacity by widening the existing bridge by constructing a new structure adjacent to the existing structure. The new roadway would include the decks of the new and existing structure, which would be joined by reinforcing steel and a concrete closure pour. Rehabilitation and strengthening of the existing bridge would be required as discussed in Alternative 1 above. The piers and abutments of the new structure would be constructed directly in line with and downstream of the existing bridge components to ensure aesthetic and hydraulic continuity of the crossing. Although widening the existing bridge would increase the traffic capacity of the crossing, it would not eliminate the nonredundant and fracture critical nature of the existing bridge or fix the problems associated with the existing bridge foundations as discussed in Alternative 1 above. This alternative was not carried forward for detailed review as a feasible alternative because the existing bridge is retained in this alternative. Widening and rehabilitating the existing bridge would cost upwards of $14 million, lane restrictions and closures would impact traffic significantly, and it would be very difficult to rehabilitate the existing foundations to add capacity. This would be a very costly and difficult alternative.

8.1.3 Alternative 3 – Construct a New Southbound Bridge

This alternative would construct a new independent structure adjacent to the existing bridge. The new structure would carry southbound traffic and the existing structure would carry northbound traffic. Rehabilitation and strengthening of the existing bridge would be required as discussed in Alternative 1 above. The piers and abutments of the new structure would be constructed directly in line with and downstream of the existing bridge components to ensure hydraulic continuity of the crossing. Aesthetically, it would be best to use a structural system that is similar to, and uses a configuration and layout that is compatible with, the existing bridge. If the depth of the superstructure is increased beyond that of the existing bridge by reducing the number of spans, the roadway profile grade line of the new structure would need to be raised to maintain the vertical clearance. This would create an undesirable visual effect due to the conflicting grade lines of the two bridges.

Although constructing a new southbound bridge would increase the capacity of the crossing, it would not eliminate the nonredundant and fracture critical nature of the existing bridge or fix the problems associated with the existing bridge foundations as discussed in Alternative 1 above. This alternative was not carried forward for detailed review as a feasible alternative because the existing bridge is retained in this alternative.

8.1.4 Alternative 4 – Construct a New Bridge with Pedestrian/Bicycle Facility on Existing Bridge

Alternative 4 would construct a new structure adjacent to the existing bridge. The new structure would carry both northbound and southbound traffic. The existing structure would be retained after the new bridge is built and would serve as a bicycle/pedestrian facility. The piers and abutments of the new structure would be constructed directly in line with and downstream of the existing bridge components to ensure hydraulic continuity of the crossing.

Aesthetically, it would be best to use a structural system that is similar to, and uses a configuration and layout that is compatible with, the existing bridge. If the depth of the superstructure is increased beyond that of the existing bridge by reducing the number of spans, the roadway profile grade line of the new structure would need to be raised to maintain the vertical clearance. This would create an undesirable visual effect of the conflicting grade lines of the two bridges.

Although constructing a new bridge for traffic would increase the capacity of the crossing, it would not eliminate the or fix the problems associated with the existing bridge foundations as discussed in Alternative 1 above. In addition, a proposed bicycle/pedestrian bridge will likely be built east of the existing bridge. This alternative was not carried forward for detailed review as a feasible alternative because the existing bridge is retained in this alternative.

8.1.5 Alternative 5 – Construct a New Bridge (phased)

This alternative would construct a new structure to replace the existing bridge using phased construction. The existing bridge would continue to carry traffic during the first phase of construction. During the second phase of construction, traffic would be routed onto the west half of the new bridge and the existing bridge would be demolished. The east half of the new bridge would then be constructed. The phased construction of the new bridge would provide traffic with unrestricted access to the crossing during construction. Additionally, the location of the piers and abutments of the new structure would be placed strategically to optimize the structural system, to be aesthetically pleasing, and to limit or reduce environmental impacts.

The phased construction of a new bridge and demolition of the existing bridge would provide an increase in capacity of the crossing, eliminate the nonredundant and fracture critical nature of the existing bridge, and alleviate the problems associated with the existing bridge foundations as discussed in Alternative 1 above. This alternative was carried forward for detailed review as a feasible alternative because the existing bridge is removed in this alternative. Bridge situation and layout sheets for Alternative 5 are shown on pages 17 through 20.

8.1.6 Alternative 6 – Construct a New Bridge on an Alternate Alignment

This alternative would construct a new bridge over the Colorado River along an alignment different from that of the existing bridge and would eventually connect back to the existing US-191. Suitable locations for a different crossing were limited by the mountain bluffs on each side of the Spanish Valley. Possible new alignments were evaluated based on the need to tie into existing roads, avoid wetlands and the Scott M. Matheson Wetland Preserve as much as possible, avoid Department of Energy lands, and fit a bridge into the geological features of the valley. One possible crossing location is a site southwest (downstream) of the existing bridge crossing along the western bluffs. This alternative would connect Kane Creek Boulevard to SR 279 (Potash Road) and would require improvements to these roads. Improvements would likely require widening the roadways, constructing intersections or interchanges, and acquiring new right-of-way, which would include residential and farmland relocations. The cost of these improvements would exceed the cost of constructing a new bridge at the existing crossing. Although this alterative would replace the existing bridge and provide continuity north and south of the new bridge, it was not carried forward for detailed review due to additional environmental concerns associated with constructing in a new portion of the river, the lack of continuity at the existing crossing, the associated cost of the improvements required to relocate the crossing, and the additional impacts to the Moab community. The existing bridge would be demolished and would not be replaced.

8.1.7 Alternative 7 – Construct a New Bridge (non-phased)

This alternative would construct a new structure adjacent to the existing bridge and then demolish the existing bridge after the new bridge is built. Additionally, the location of the piers and abutments of the new structure could be placed strategically to optimize the structural systems, to be aesthetically pleasing, and to limit or reduce environmental impacts.

Constructing a new bridge and demolishing the existing bridge would increase the capacity of the crossing, eliminate the nonredundant and fracture critical nature of the existing bridge, and alleviate the problems associated with the existing bridge foundations as discussed in Alternative 1 above. This alternative was carried forward for detailed review as a feasible alternative because the existing bridge is removed in this alternative. Bridge situation and layout sheets for Alternative 7 are shown on pages 21 through 24.

8.2 Cost Estimates

Cost estimates were developed for Alternatives 1, 5, and 7.

Alternative 1

Alternative 1 (No Build/No Action) is carried forward as a baseline cost as determined by federal NEPA requirements. This alternative has been deemed not feasible but the cost of the rehabilitation items listed in Section 8.1.1 is estimated at $6.5 million. This would rehabilitate the bridge up to the condition when it was built and a better sufficiency rating. It will not increase capacity and will not widen the shoulders. The rehabilitation to the existing bridge will also severely affect traffic which, in turn, would severely affect the community since the alternate route is very lengthy.

Alternatives 5 and 7

Superstructure quantities are included on the situation and layout sheets for each alternative on pages 17 through 24. Substructure quantities are shown on the substructure options sheets on pages 25 and 26. The unit costs for calculating the estimates are given in Table 6.

Table 6. Unit Cost of Bridge Items[a]

Item	Unit	Unit Cost
Structural concrete	cu yd	$350
Reinforcing steel (coated)	lb	$1.00
Structural steel	lb	$1.75
Prestressed concrete members	ft	$190
Driven piles[b]	ft	$60

[a] Based on average 2004 prices.
[b] Applicable for Substructure Option C only.

The estimates for Alternatives 5 and 7 were used to compare the minimum and maximum cost of each bridge configuration. Alternatives 5 and 7 are identical except for the construction process. For comparison the average cost of the substructure options A, B, and C were used in the estimates. The following assumptions were made in determining the estimates:

- 2.5% increase for incidental items.
- 6% increase for working over water.
- 7.5% increase for mobilization.
- 10% increase for contingencies.
- 5% increase for Alternatives 5 due to the phased construction.
- The cost of two abutments was $670,000 which is equal to the average cost of materials for one pier.
- The average cost per pier was $670,000.
- An additional cost of $250,000 was included for construction means (barge, temporary causeway, wood trestle, etc.) to place piers in the river channel.
- Estimates are for the cost of constructing the bridge and do not include improvements to the roadway within the study corridor.

The following is a brief description of the bridge configurations.

- **Configuration 1.** A 7-span bridge with precast prestressed AASHTO Type VI girders
- **Configuration 2.** A 4-span bridge with steel plate girders
- **Configuration 3.** A 5-span bridge with steel plate girders
- **Configuration 4.** A 6-span bridge with steel plate girders

The estimated cost of each alternative and its corresponding configurations are listed in the following tables.

Table 7. Estimated Cost of Bridge Alternatives

	Alternative 5	Alternative 7
Configuration 1	$12,152,275	$11,573,595
Configuration 2	$13,819,868	$13,161,779
Configuration 3	$13,188,904	$12,560,861
Configuration 4	$13,475,108	$12,833,436

Table 8. Estimated Square Foot Cost of Bridge Alternatives

	Alternative 5[a]	Alternative 7[a]
Configuration 1	$150	$143
Configuration 2	$170	$162
Configuration 3	$163	$155
Configuration 4	$166	$158

[a] Alternatives 5 and 7 are based on an area of 81,157 ft^2.

It is recommended that a more detailed type selection report be developed after a preferred alignment and roadway cross-section have been selected. A hydraulic study and geotechnical investigation are recommended for determining the best-suited substructure type and layout.

8.3 Construction Issues

The construction of a new bridge will require construction activities in the water, in the river bed, and along the shoreline. The method for constructing the piers varies depending on the type of deep foundation selected. Construction methods such as cofferdams may be required for building the piers in the river. Dewatering may also be required at other locations where groundwater is present. All necessary permits should be obtained before construction to prevent work stoppages due to regulatory requirements. Phased construction is used for Alternative 5 to minimize the distance the centerline would be moved downstream of the existing structure while continuing to provide access to traffic throughout construction.

8.4 Inspection and Maintenance Requirements

Biannual routine inspections and maintenance requirements are anticipated for typical bridge types commonly used by UDOT. An underwater inspection of permanent elements should be conducted every 5 years for evaluating the condition of the substructure below the water. If an unusual structure type such as an arch, truss, cable-stayed, or suspension bridge were constructed, then special requirements for inspection and maintenance should be specified by the designer.

8.5 Signature Structures

Signature structures such as arch, truss, cable-stayed, or suspension bridges were not included in this study. This does not exclude their use at this location should funding become available. A signature structure could provide an aesthetic entrance into Moab.

8.6 Bridge Situation and Layout Sheets

Bridge preliminary situation and layout sheets for Alternatives 5, 7, and substructure options are provided on pages 17 through 26. For these two alternatives separate situation and layout sheets are shown using the following configurations:

- **Configuration 1.** A 7-span bridge with precast prestressed AASHTO Type VI girders
- **Configuration 2.** A 4-span bridge with steel plate girders
- **Configuration 3.** A 5-span bridge with steel plate girders
- **Configuration 4.** A 6-span bridge with steel plate girders

The shoulder widths shown on the preliminary situation and layout sheets may be modified based on approved design exceptions received prior to final design of the roadway.

8.7 Recommendations

A safer crossing over the Colorado River for vehicles, bicyclists, and pedestrians can be provided with a new bridge that can carry increasing traffic volumes and is designed to current AASHTO LRFD Bridge Design Specifications. Due to the insufficiencies of the existing bridge, including its lack of redundancy, fracture critical nature, inadequate safety features, and unknown condition of the substructure, Alternatives 1, 2, 3, and 4 were eliminated from further consideration. Alternative 6 was also eliminated because a feasible location to reroute the alignment was not available, the lack of continuity to the Moab community, and the cost of a new alignment and other improvements exceeded that of the other alternatives. The two remaining alternatives are Alternatives 5 and 7. The major difference between these options is the construction sequencing and location of the new centerline with respect to the existing bridge. Typical roadway cross-sections for Alternatives 5 and 7 are shown in Figures 7.

The process used to construct Alternative 7 is simpler because no phasing is required; however, it impacts a larger area outside the footprint of the existing bridge than does Alternative 5. The phased construction process used for Alternative 5 minimizes the area impacted outside the footprint of the existing bridge and the need for additional right-of-way. For these reasons, Alternative 5 is the recommended alternative. Based on the above conclusion, the estimated cost of Alternative 5 depending on the roadway cross-section and the substructure type ranges from $12.1 million to $13.8 million.

9.0 ENVIRONMENTAL ISSUES

HDR conducted NEPA scoping and preliminary environmental review for the study to determine whether an Environmental Assessment or an Environmental Impact Study would be appropriate for the proposed action.

The NEPA scoping activities are summarized in Section 2.0. The preliminary environmental review included the following activities as outlined below.

9.1 Cultural Resources

A Class I Cultural Resource Study was conducted at the Utah State Historical Preservation Office and the BLM Moab Field Office. The report of this search indicates that there is a historic property (the Arthur Taylor House) at 1266 N. Hwy 191 and eight previously recorded archaeological sites in the project area. Some of the rock panels and granaries along the cliffs and talus slopes between the Colorado River and Courthouse Wash in Arches National Park that are known to exist could not be located in the literature. Locating these panels will be a part of the next phase of environmental work. The report also states that the Colorado River Bridge itself will require documentation if structural modification or replacement occurs. Results are summarized in the Draft Class I Resource Study for the Colorado River Bridge Project, Grand County, Utah, dated July 20, 2004, prepared by Montgomery Archeological Consultants. UDOT sent the Class I Cultural Resource Study to the Hopi Tribe, BLM, National Park Service, and Department of Energy. UDOT also requested a fossil record search at the Utah Geological Survey. There are two fossil trackway locations in the study area.

9.2 Threatened and Endangered Species

A preliminary field survey for threatened and endangered species was conducted in June 2004. The survey recommended coordination with USFWS concerning threatened fish species in the Colorado River and potentially a raptor survey.

9.3 Recommendations

Based on results of the preliminary activities listed above, it is not anticipated that constructing a new bridge will have a significant impact on the environment. Therefore, an Environmental Assessment (EA) is anticipated. Consultation with FHWA on this issue is recommended. Consultation with the agencies listed in the Scoping Summary Report is also recommended during the next phase of the project. If significant environmental impacts are discovered during a later phase of the project, an Environmental Impact Study (EIS) may be required. A Notice of Intent (NOI) will need to be filed if this determination is made; no NOI has been filed to date.

9.4 Other Environmental Project Documents

The following documents are on file with HDR or UDOT:

Draft Chapter 1 Purpose and Need – July 2004, HDR

Draft Chapter 2 Alternatives – July 2004, HDR

Draft Environmental Scope of Work – July 2004, by HDR

Recommended Environmental Document Memo – July 2004, HDR

Threatened and Endangered Species Memo – July 2004, HDR

Class I Cultural Resource Study – July 20, 2004, Montgomery Archeological Consultants

10.0 RECOMMENDATIONS FOR FUTURE ACTION

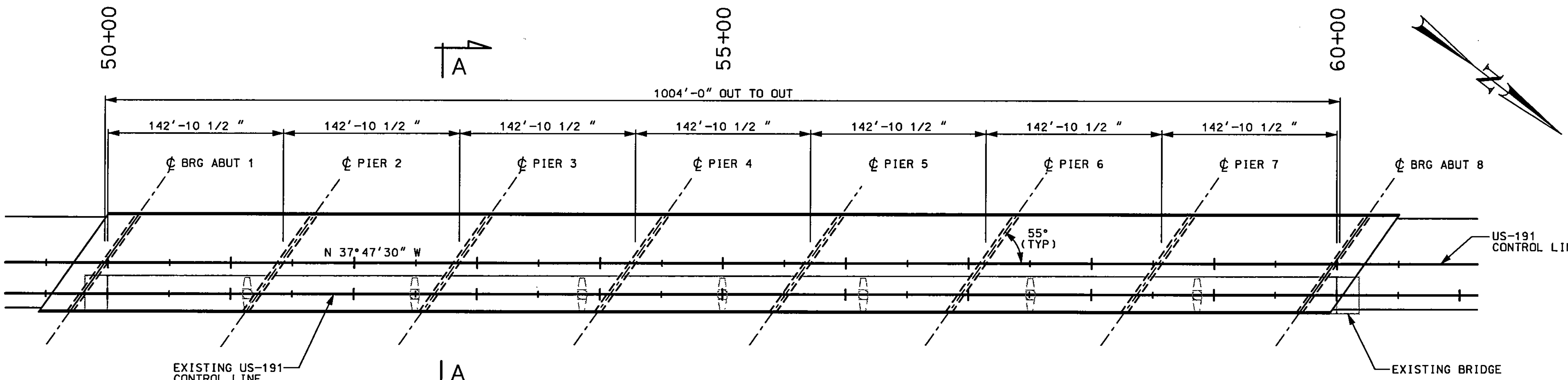
A detailed geotechnical investigation at each proposed bridge support location is recommended for determining depth to bedrock/hard layer for column/pile lengths and for design purposes. The foundations located on the point bar will need to be placed at an elevation that will prevent deterioration of the substructure due to scour effects as the channel migrates with time and flooding.

A detailed hydraulics investigation is recommended at the bridge site using the proposed substructure units to determine scour effects on the new bridge. A complete HEC-RAS analysis would be conducted using the proposed pier configurations and skew and using data from the geotechnical investigation.

The recommended alternative is Alternative 5, which consists of a 4-span hybrid steel plate girder bridge. This alternative minimizes the work required in the river and other environmentally sensitive areas. The phased construction process minimizes the area of impact beyond the area impacted by the existing bridge. The drilled shaft substructure option B appears to be the most likely pier type. We recommend proceeding with the Environmental Assessment using Alternative 5.

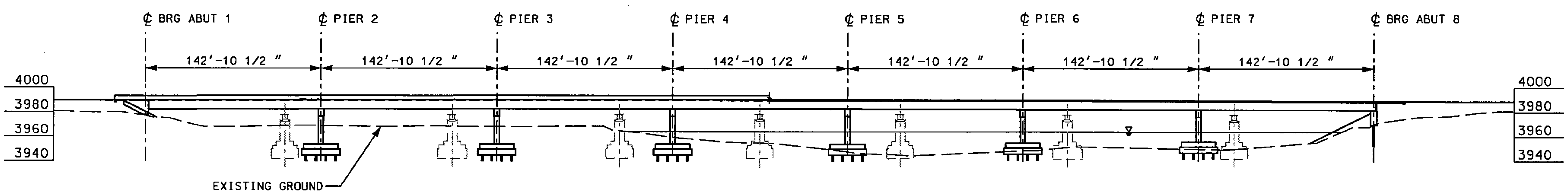
We further recommend that the proposed bridge should not be shortened on the south bank since this would significantly affect the hydraulic opening of the Colorado River by building an approach causeway with fill. The causeway would require extensive geotechnical testing and design to ensure that the fill does not erode with the river flow and does not subside in the river mud. Extensive coordination with the USACE would be required since the causeway would be built inside the limits of the river banks. The river channel should be left as-is since it is difficult to predict what unintended consequences the change could produce downstream and upstream to the river channel and banks.

ALTERNATIVE 5 - 7 SPANS WITH PRESTRESSED CONCRETE GIRDERS



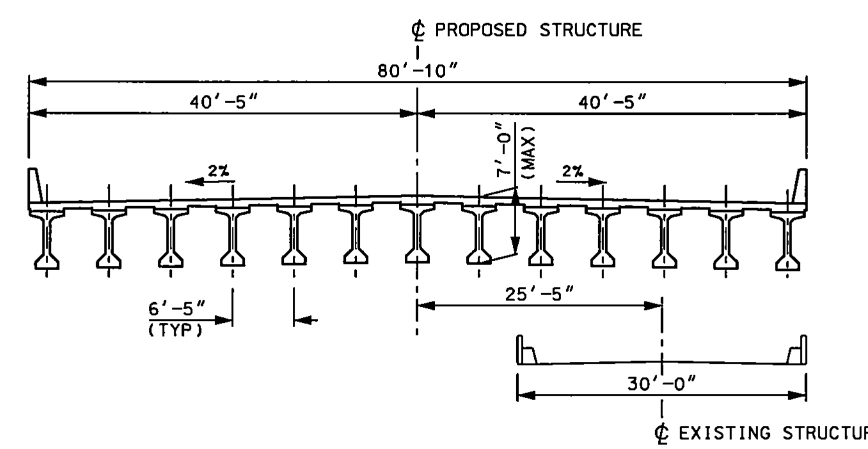
PLAN

SCALE: 1"=100'



ELEVATION

SCALE: 1"=100'



SECTION A-A

SCALE: 1"=20'

SUPERSTRUCTURE QUANTITIES

DESCRIPTION	QUANTITY	UNIT
STRUCTURAL CONCRETE	3,182	YD^3
REINFORCING STEEL	507,561	LB
PRESTRESSED CONCRETE MEMBER	13,000	FT
SQ FT DECK	81,157	FT^2

NOTE:
THE STRUCTURE SHOWN IS CONCEPTUAL ONLY.
THE BRIDGE TYPE AND STRUCTURE ELEMENTS WOULD BE ADJUSTED TO BEST FIT THE TERRAIN AND FINAL DESIGN REQUIREMENTS.

PRELIMINARY - NOT FOR CONSTRUCTION

REVISIONS

NO.	DATE	BY	REMARKS

UTAH DEPARTMENT OF TRANSPORTATION
REGION 4, RICHFIELD, UTAH
HDR ENGINEERING, INC.

DESIGN ___ CHECK ___
DRAWN ___ CHECK ___
QUANT. ___ CHECK ___
APPROVAL RECOMM. ___ DATE ___ SENIOR DESIGN ENGR.
APPROVED FOR USE BY UDOT ___ DATE ___ UDOT BRIDGE ENGR.

US-191 OVER COLORADO RIVER
COLORADO RIVER BRIDGE STUDY
ALTERNATIVE 5

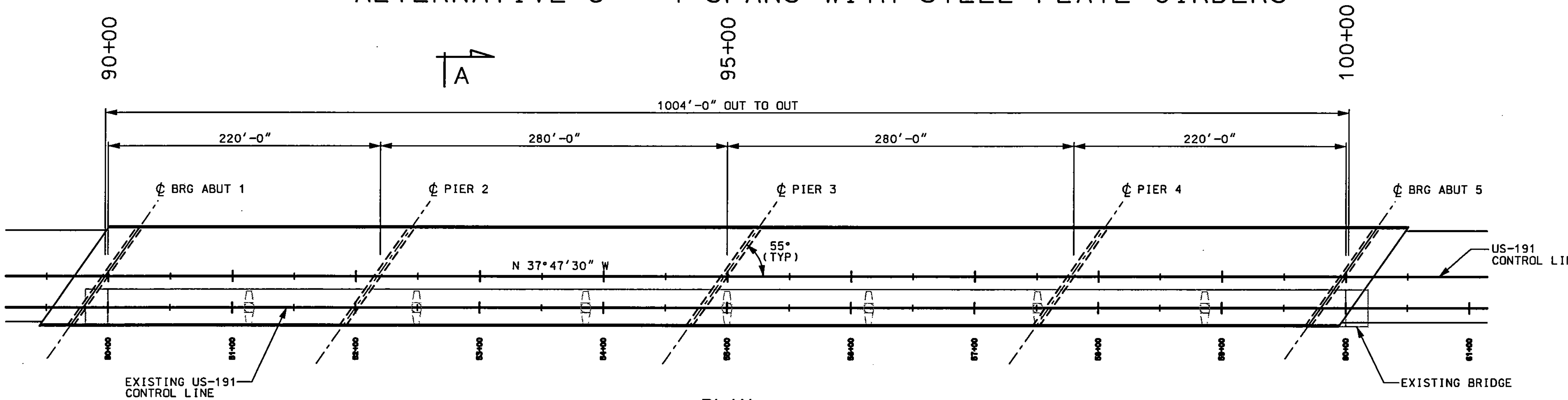
PROJECT NUMBER BRF-0191(23)128

GRAND
COUNTY

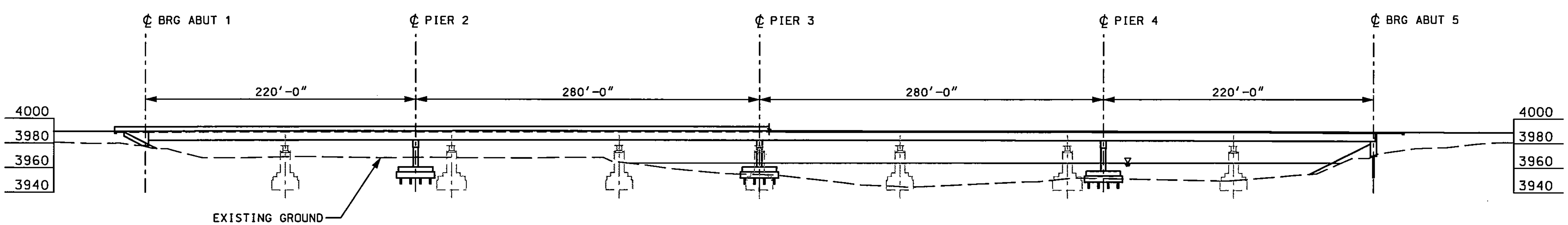
DRG. NO.

SHT. 17

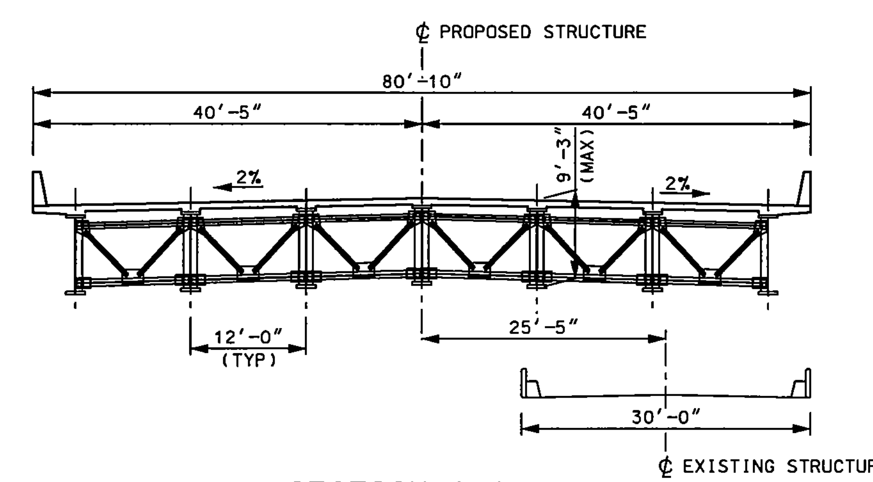
ALTERNATIVE 5 - 4 SPANS WITH STEEL PLATE GIRDERS



PLAN
SCALE: 1"=100'



ELEVATION
SCALE: 1"=100'



SECTION A-A
SCALE: 1"=20'

SUBSTRUCTURE QUANTITIES

DESCRIPTION	QUANTITY	UNIT
STRUCTURAL CONCRETE	2,686	YD^3
REINFORCING STEEL	558,716	LB
STRUCTURAL STEEL	3,354,750	LB
SQ FT DECK	81,157	FT^2

NOTE:
THE STRUCTURE SHOWN IS CONCEPTUAL ONLY. THE BRIDGE TYPE AND STRUCTURE ELEMENTS WOULD BE ADJUSTED TO BEST FIT THE TERRAIN AND FINAL DESIGN REQUIREMENTS.

PRELIMINARY - NOT FOR CONSTRUCTION

REVISIONS
NO. | DATE | BY | REMARKS

UTAH DEPARTMENT OF TRANSPORTATION
REGION 4, RICHFIELD, UTAH
HDR ENGINEERING, INC.

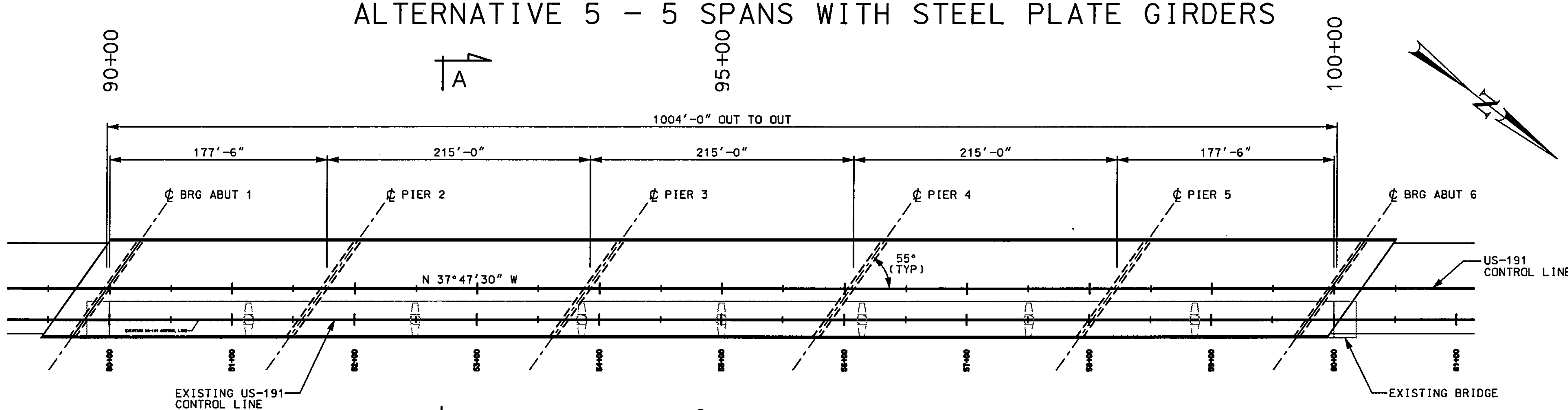
DESIGN ____ CHECK ____
DRAWN ____ CHECK ____
QUANT. ____ CHECK ____
APPROVAL RECOMM. ____ DATE ____ SENIOR DESIGN ENGR.
APPROVED FOR USE BY UDOT ____ DATE ____ UDOT BRIDGE ENGR.

US-191 OVER COLORADO RIVER
COLORADO RIVER BRIDGE STUDY
ALTERNATIVE 5
PROJECT NUMBER BRF-0191(23)128

GRAND
COUNTY

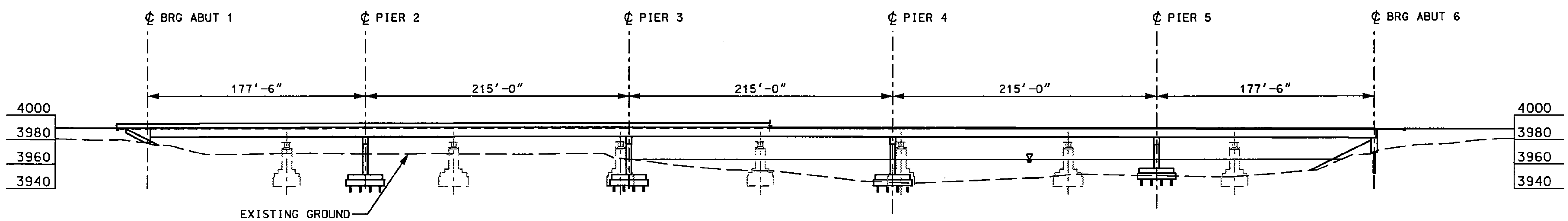
DRG. NO.
SHT. 18

ALTERNATIVE 5 – 5 SPANS WITH STEEL PLATE GIRDERS



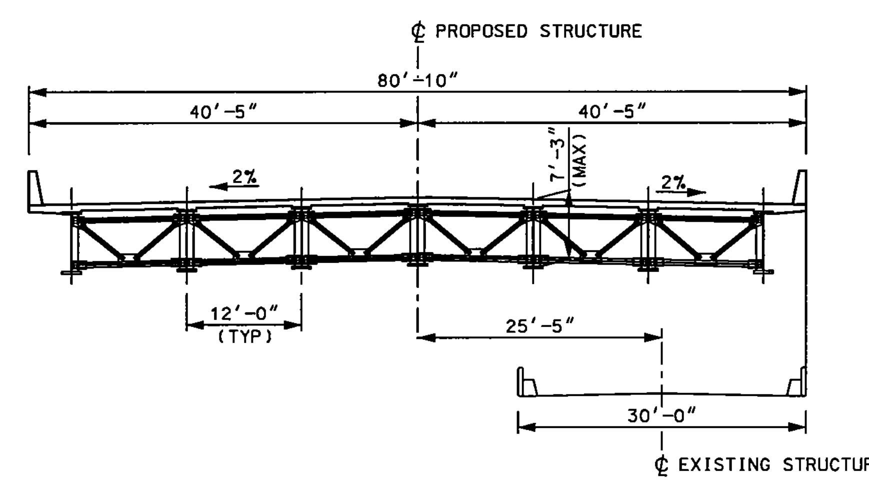
PLAN

SCALE: 1"=100'



ELEVATION

SCALE: 1"=100'



SECTION A-A

SCALE: 1"=20'

SUPERSTRUCTURE QUANTITIES

DESCRIPTION	QUANTITY	UNIT
STRUCTURAL CONCRETE	2,686	YD^3
REINFORCING STEEL	558,716	LB
STRUCTURAL STEEL	2,704,625	LB
SQ FT DECK	81,157	FT^2

NOTE:
THE STRUCTURE SHOWN IS CONCEPTUAL ONLY.
THE BRIDGE TYPE AND STRUCTURE ELEMENTS
WOULD BE ADJUSTED TO BEST FIT THE TERRAIN
AND FINAL DESIGN REQUIREMENTS.

PRELIMINARY - NOT FOR CONSTRUCTION

NO. | DATE | BY | REMARKS
REVISIONS

UTAH DEPARTMENT OF TRANSPORTATION
REGION 4, RICHFIELD, UTAH
HDR ENGINEERING, INC.

DESIGN | CHECK
DRAWN | CHECK
QUANT. | CHECK
APPROVAL RECOMM. | DATE | SENIOR DESIGN ENGR.
APPROVED FOR USE BY UDOT | DATE | UDOT BRIDGE ENGR.

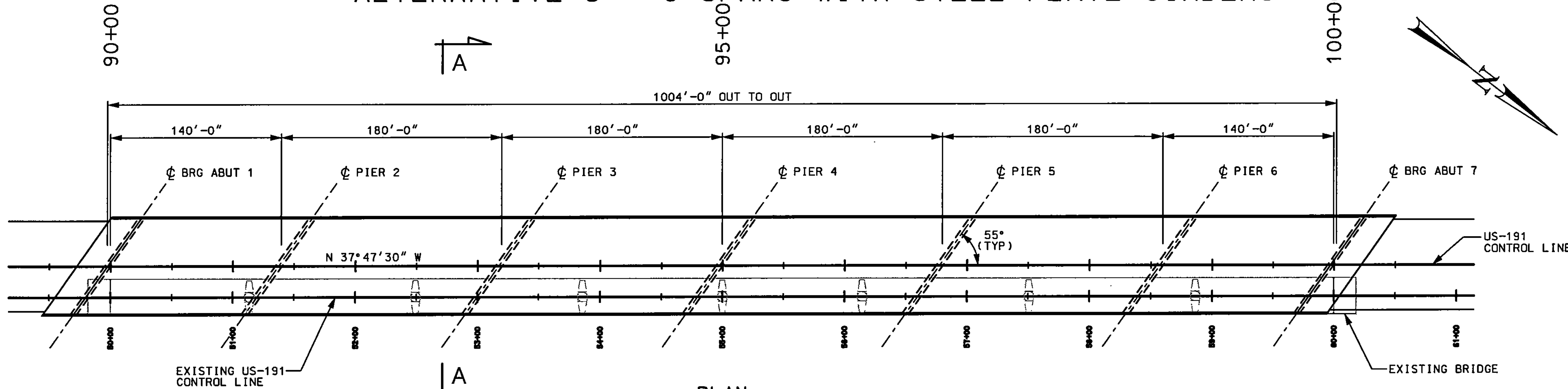
US-191 OVER COLORADO RIVER
COLORADO RIVER BRIDGE STUDY
ALTERNATIVE 5
PROJECT NUMBER BRF-0191(23)128

GRAND
COUNTY

DRG. NO.

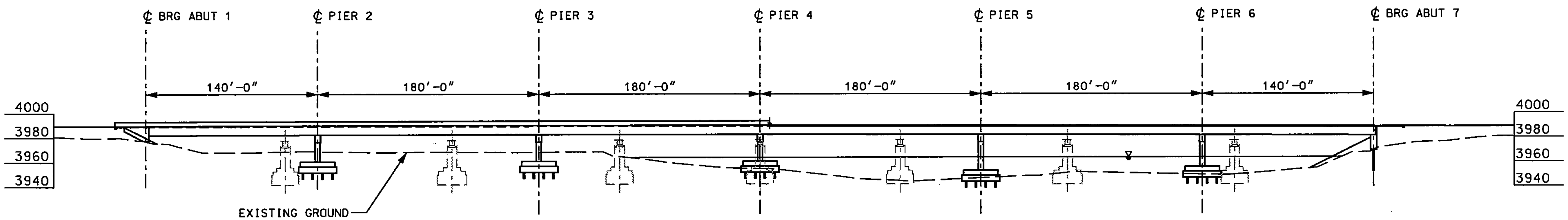
SHT. 19

ALTERNATIVE 5 - 6 SPANS WITH STEEL PLATE GIRDERS



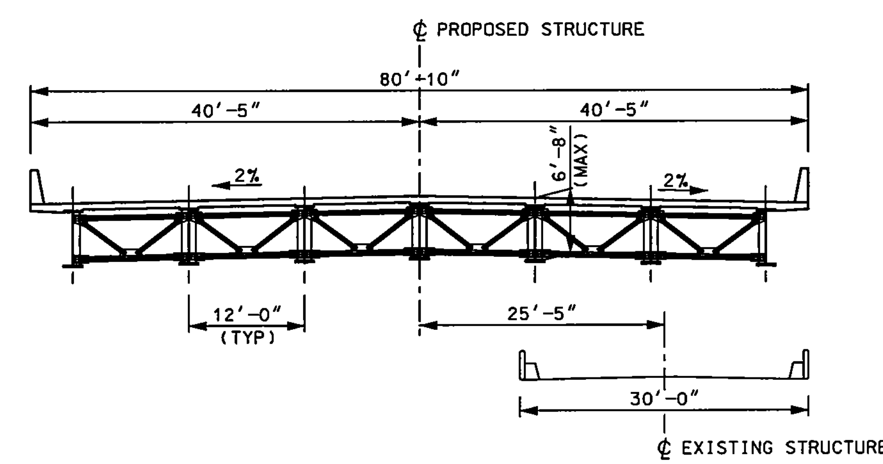
PLAN

SCALE: 1"=100'



ELEVATION

SCALE: 1"=100'



SECTION A-A

SCALE: 1"=20'

SUPERSTRUCTURE QUANTITIES

DESCRIPTION	QUANTITY	UNIT
STRUCTURAL CONCRETE	2,686	YD^3
REINFORCING STEEL	558,716	LB
STRUCTURAL STEEL	2,443,000	LB
SQ FT DECK	81,157	FT^2

NOTE:
THE STRUCTURE SHOWN IS CONCEPTUAL ONLY. THE BRIDGE TYPE AND STRUCTURE ELEMENTS WOULD BE ADJUSTED TO BEST FIT THE TERRAIN AND FINAL DESIGN REQUIREMENTS.

PRELIMINARY - NOT FOR CONSTRUCTION

UTAH DEPARTMENT OF TRANSPORTATION
REGION 4, RICHFIELD, UTAH
HDR ENGINEERING, INC.

US-191 OVER COLORADO RIVER
COLORADO RIVER BRIDGE STUDY
ALTERNATIVE 5

PROJECT NUMBER BRF-0191(23)128

REVISIONS | NO. | DATE | BY | REMARKS

DESIGN | CHECK | DRAWN | CHECK | QUANT. | CHECK

APPROVAL RECOMM. | DATE | SENIOR DESIGN ENGR.

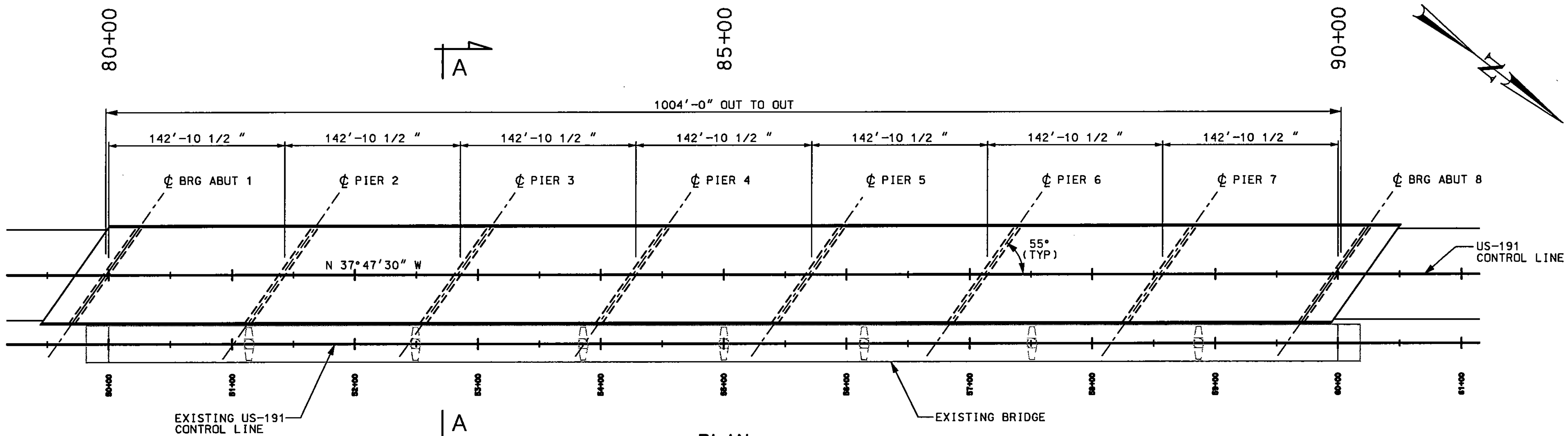
APPROVED FOR USE BY UDOT | DATE | UDOT BRIDGE ENGR.

GRAND COUNTY

DRG. NO.

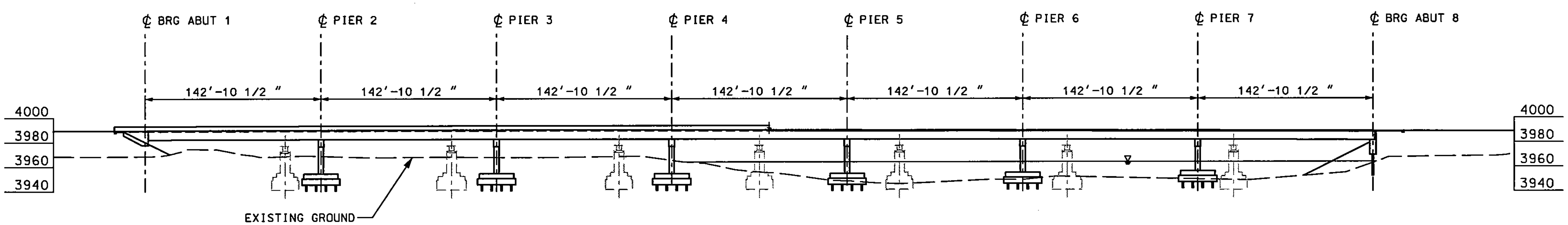
SHT. 20

ALTERNATIVE 7 - 7 SPANS WITH PRESTRESSED CONCRETE GIRDERS



PLAN

SCALE: 1"=100'

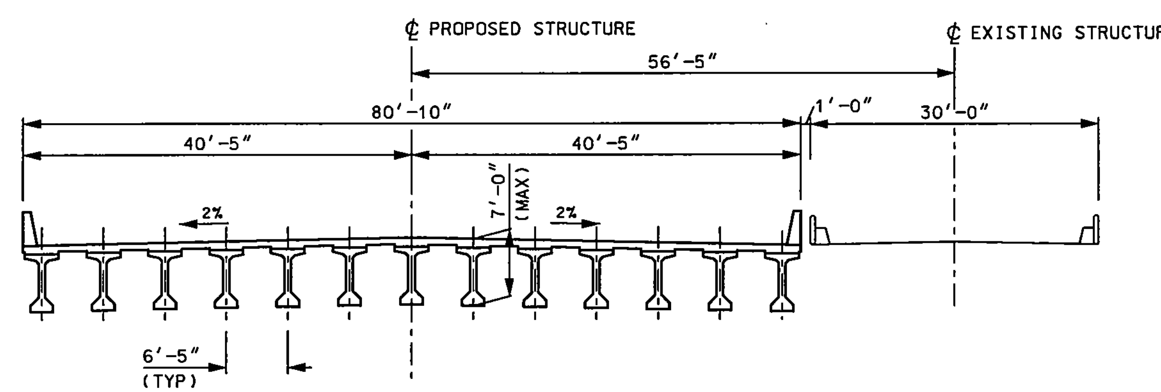


ELEVATION

SCALE: 1"=100'

SUPERSTRUCTURE QUANTITIES

DESCRIPTION	QUANTITY	UNIT
STRUCTURAL CONCRETE	3,182	YD^3
REINFORCING STEEL	507,561	LB
PRESTRESSED CONCRETE MEMBER	13,000	FT
SQ FT DECK	81,157	FT^2



SECTION A-A

SCALE: 1"=20'

NOTE:
THE STRUCTURE SHOWN IS CONCEPTUAL ONLY.
THE BRIDGE TYPE AND STRUCTURE ELEMENTS
WOULD BE ADJUSTED TO BEST FIT THE TERRAIN
AND FINAL DESIGN REQUIREMENTS.

PRELIMINARY - NOT FOR CONSTRUCTION

REVISIONS

NO.	DATE	BY	REMARKS

UTAH DEPARTMENT OF TRANSPORTATION
REGION 4, RICHFIELD, UTAH
HDR ENGINEERING, INC.

DESIGN ____ CHECK ____
DRAWN ____ CHECK ____
QUANT. ____ CHECK ____
APPROVAL RECOMM. ____ DATE ____ SENIOR DESIGN ENGR.
APPROVED FOR USE BY UDOT ____ DATE ____ UDOT BRIDGE ENGR.

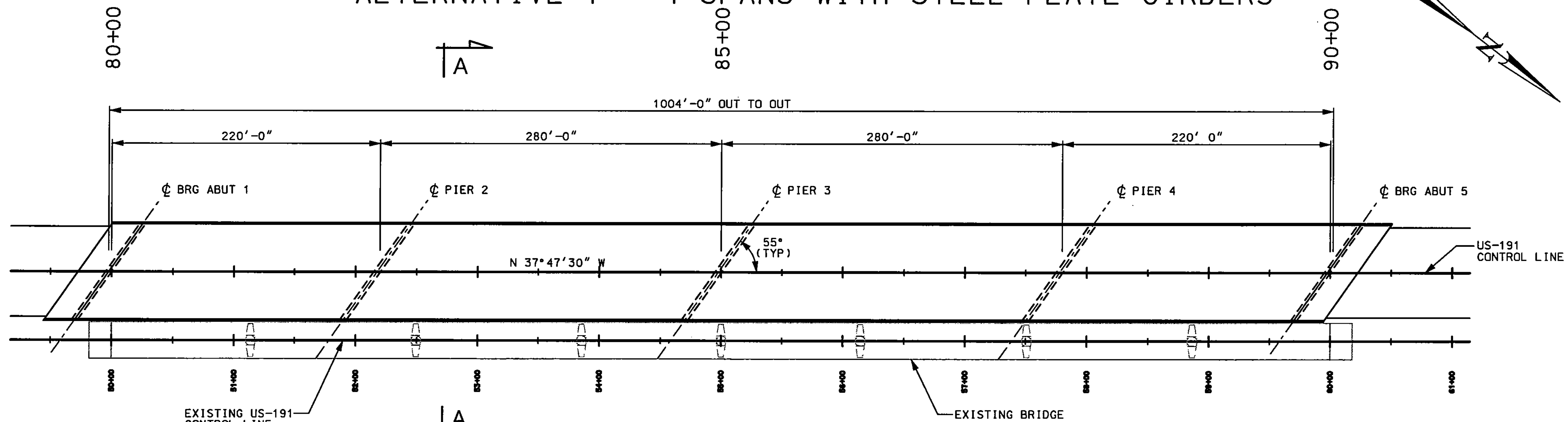
US-191 OVER COLORADO RIVER
COLORADO RIVER BRIDGE STUDY
ALTERNATIVE 7
PROJECT NUMBER BRF-0191(23)128

GRAND
COUNTY

DRG. NO.

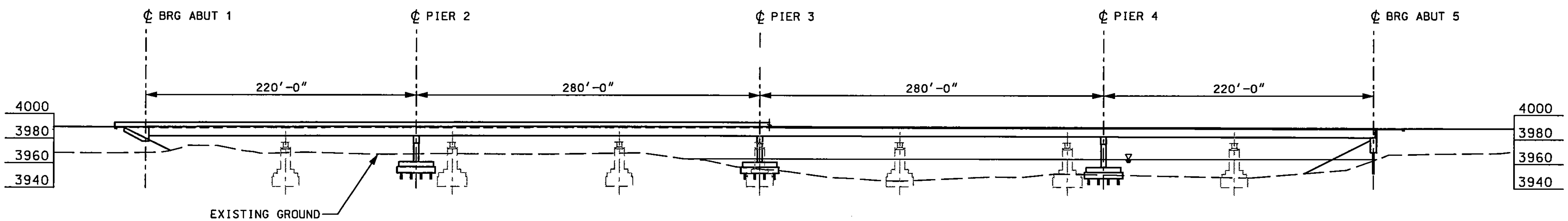
SHT. 21

ALTERNATIVE 7 – 4 SPANS WITH STEEL PLATE GIRDERS



PLAN

SCALE: 1"=100'

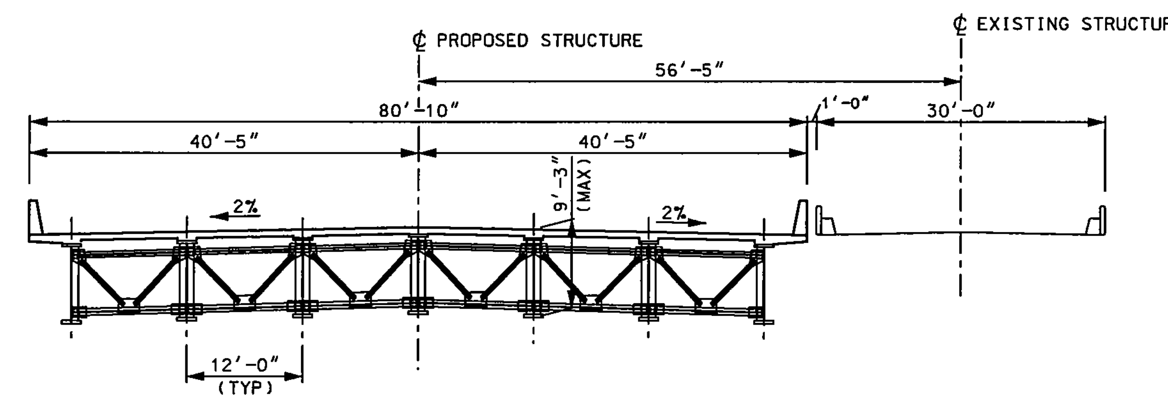


ELEVATION

SCALE: 1"=100'

SUPERSTRUCTURE QUANTITIES

DESCRIPTION	QUANTITY	UNIT
STRUCTURAL CONCRETE	2,686	YD^3
REINFORCING STEEL	558,716	LB
STRUCTURAL STEEL	3,354,750	LB
SQ FT DECK	81,157	FT^2



SECTION A-A

SCALE: 1"=20'

NOTE:
THE STRUCTURE SHOWN IS CONCEPTUAL ONLY.
THE BRIDGE TYPE AND STRUCTURE ELEMENTS
WOULD BE ADJUSTED TO BEST FIT THE TERRAIN
AND FINAL DESIGN REQUIREMENTS.

PRELIMINARY – NOT FOR CONSTRUCTION

REVISIONS

NO.	DATE	BY	REMARKS

UTAH DEPARTMENT OF TRANSPORTATION
REGION 4, RICHFIELD, UTAH
HDR ENGINEERING, INC.

DESIGN ____ CHECK ____
DRAWN ____ CHECK ____
QUANT. ____ CHECK ____

APPROVAL RECOMM. ____ DATE ____ SENIOR DESIGN ENGR.
APPROVED FOR USE BY UDOT ____ DATE ____ UDOT BRIDGE ENGR.

US-191 OVER COLORADO RIVER
COLORADO RIVER BRIDGE STUDY
ALTERNATIVE 7
PROJECT NUMBER BRF-0191(23)128

GRAND
COUNTY

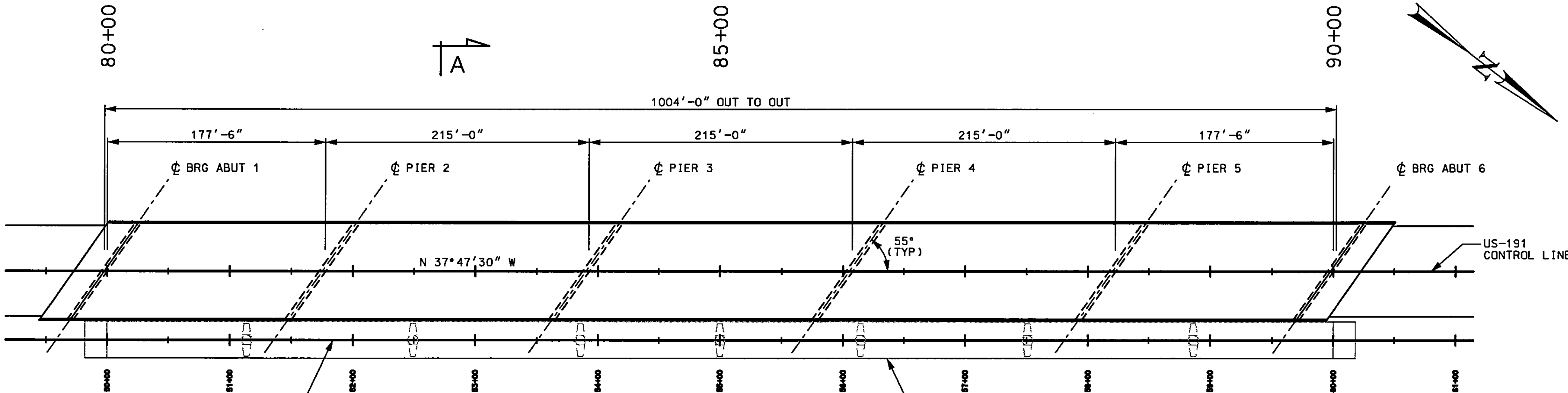
DRG. NO.

SHT. 22

...\Steel 4 span\3418_alt7_s4.dgn 11/09/2004 05:26:00 PM PrinterBW.plt

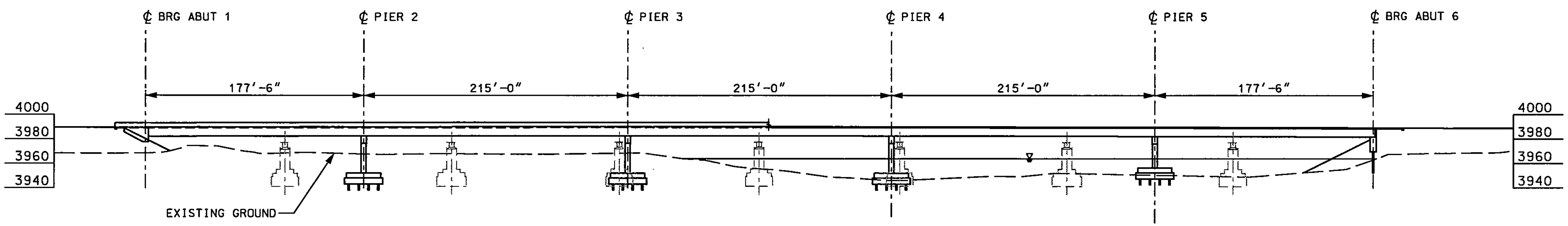
11/09/2004 05:26:01 PM \\SLC-BDC\projdocs\Colorado River Bridge Study\3418_04\Sheet_Files\Structures\Steel4 span\3418_alt7_s4.dgn

ALTERNATIVE 7 - 5 SPANS WITH STEEL PLATE GIRDERS



PLAN

SCALE: 1"=100'

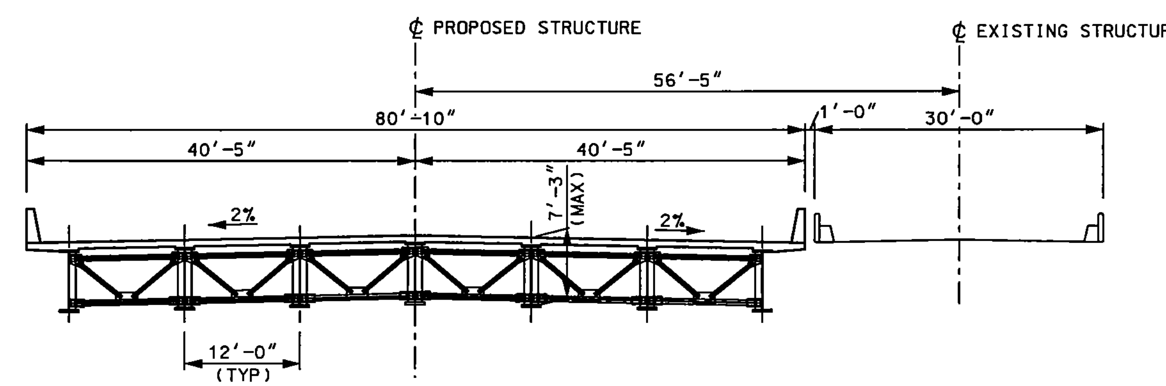


ELEVATION

SCALE: 1"=100'

SUPERSTRUCTURE QUANTITIES

DESCRIPTION	QUANTITY	UNIT
STRUCTURAL CONCRETE	2.686	YD^3
REINFORCING STEEL	558.716	LB
STRUCTURAL STEEL	2.704.625	LB
SQ FT DECK	81.157	FT^2



SECTION A-A

SCALE: 1"=20'

NOTE:
THE STRUCTURE SHOWN IS CONCEPTUAL ONLY.
THE BRIDGE TYPE AND STRUCTURE ELEMENTS
WOULD BE ADJUSTED TO BEST FIT THE TERRAIN
AND FINAL DESIGN REQUIREMENTS.

PRELIMINARY - NOT FOR CONSTRUCTION

REVISIONS
NO. | DATE | BY | REMARKS

UTAH DEPARTMENT OF TRANSPORTATION
REGION 4, RICHFIELD, UTAH
HDR ENGINEERING, INC.

DESIGN | CHECK
DRAWN | CHECK
QUANT. | CHECK
APPROVAL RECOMM. | DATE | SENIOR DESIGN ENGR.
APPROVED FOR USE BY UDOT | DATE | UDOT BRIDGE ENGR.

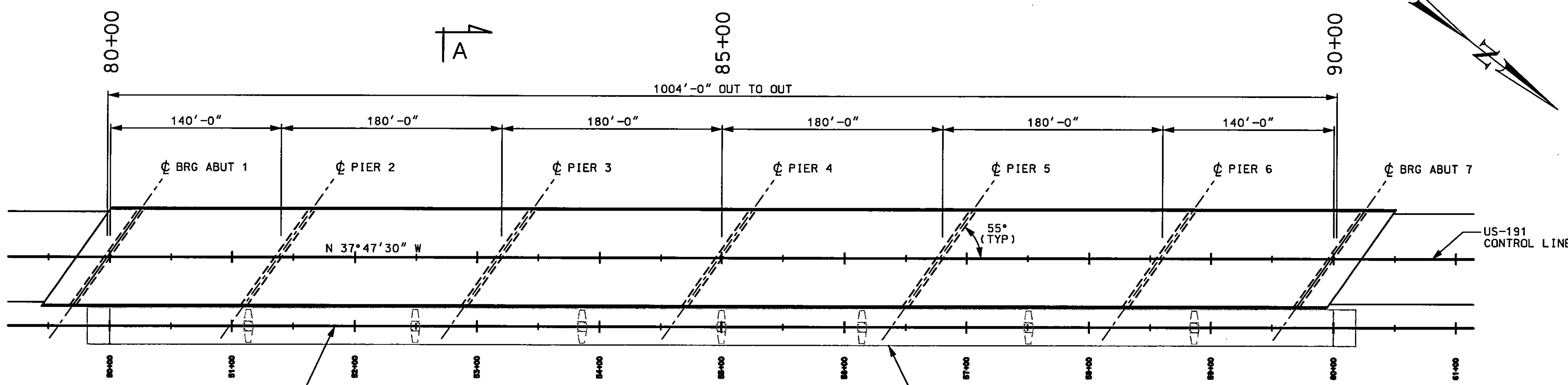
US-191 OVER COLORADO RIVER
COLORADO RIVER BRIDGE STUDY
ALTERNATIVE 7
PROJECT NUMBER BRF-0191(23)128

GRAND
COUNTY

DRG. NO.

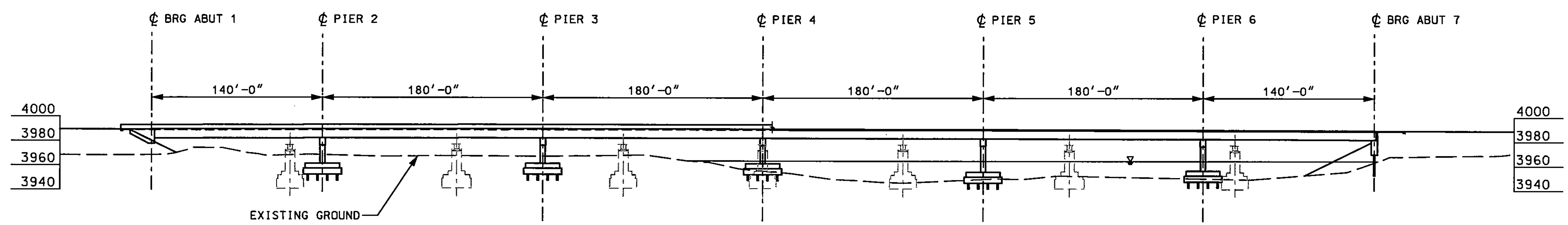
SHT. 23

ALTERNATIVE 7 - 6 SPANS WITH STEEL PLATE GIRDERS



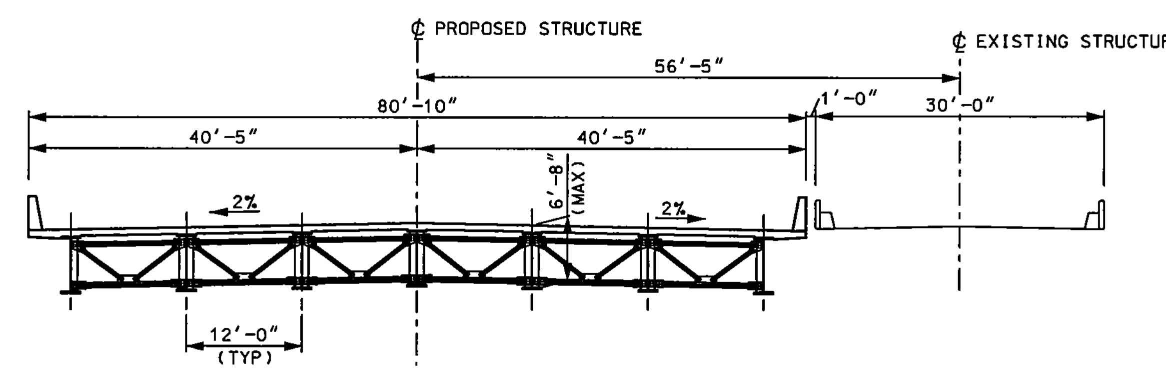
PLAN

SCALE: 1"=100'



ELEVATION

SCALE: 1"=100'



SECTION A-A

SCALE: 1"=20'

SUPERSTRUCTURE QUANTITIES

DESCRIPTION	QUANTITY	UNIT
STRUCTURAL CONCRETE	2,686	YD^3
REINFORCING STEEL	558,716	LB
STRUCTURAL STEEL	2,443,000	LB
SQ FT DECK	81,157	FT^2

NOTE:
THE STRUCTURE SHOWN IS CONCEPTUAL ONLY. THE BRIDGE TYPE AND STRUCTURE ELEMENTS WOULD BE ADJUSTED TO BEST FIT THE TERRAIN AND FINAL DESIGN REQUIREMENTS.

PRELIMINARY - NOT FOR CONSTRUCTION

REVISIONS
NO. | DATE | BY | REMARKS

UTAH DEPARTMENT OF TRANSPORTATION
REGION 4, RICHFIELD, UTAH
HDR ENGINEERING, INC.

DESIGN | CHECK
DRAWN | CHECK
QUANT. | CHECK
APPROVAL RECOM. | DATE | SENIOR DESIGN ENGR.
APPROVED FOR USE BY UDOT | DATE | UDOT BRIDGE ENGR.

US-191 OVER COLORADO RIVER
COLORADO RIVER BRIDGE STUDY
ALTERNATIVE 7
PROJECT NUMBER BRF-0191(23)128

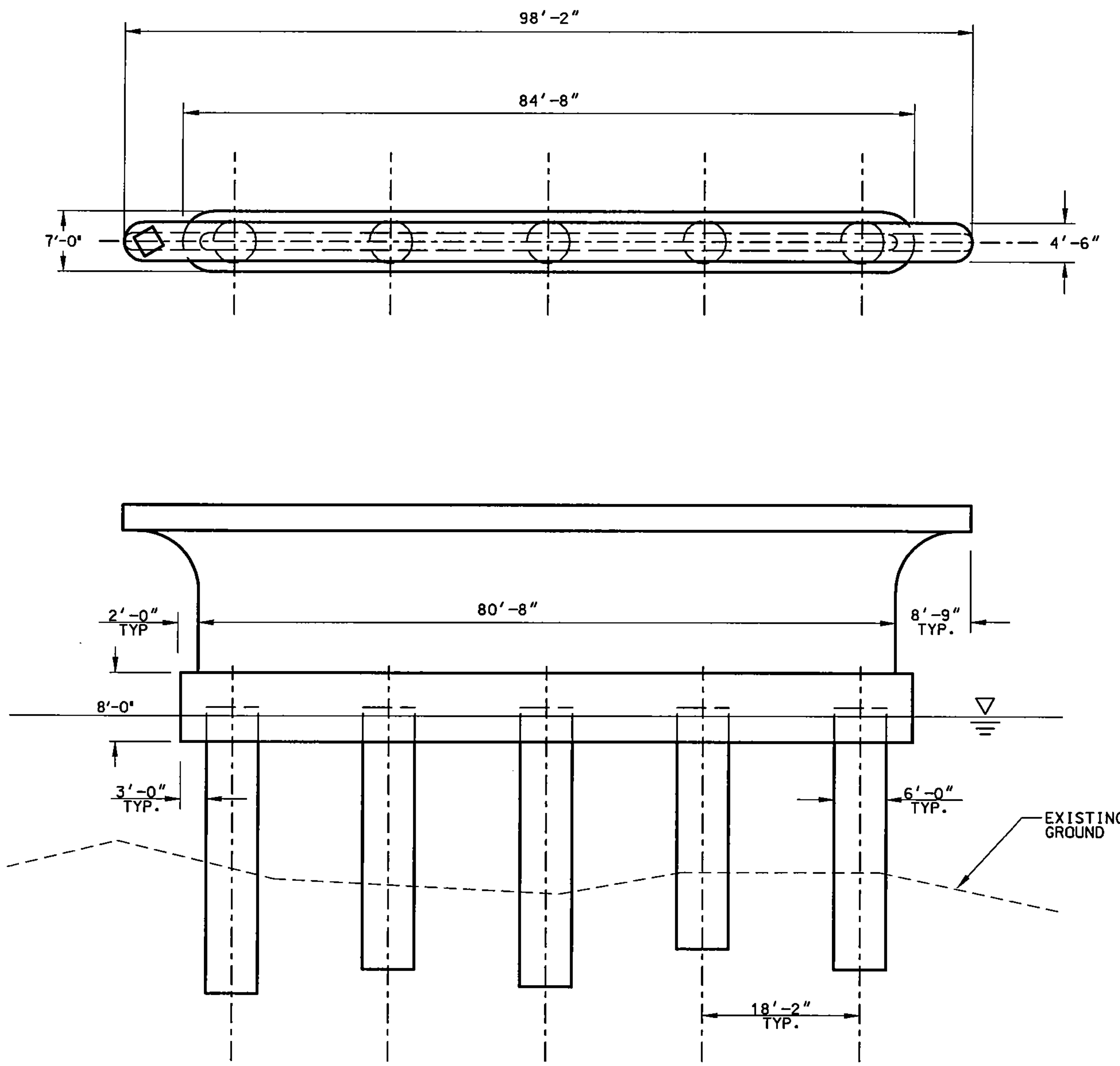
GRAND COUNTY

DRG. NO.

SHT. 24

11/09/2004 05:27:03 PM \\SLC-BDC1\projdocs\Colorado River Bridge Study\3418_04\Sheet_Files\Structures\Steel6_span\3418_alt7_s6.dgn

...\Steel 6 span\3418_alt7_s6.dgn 11/09/2004 05:27:03 PM PrinterBW.plt



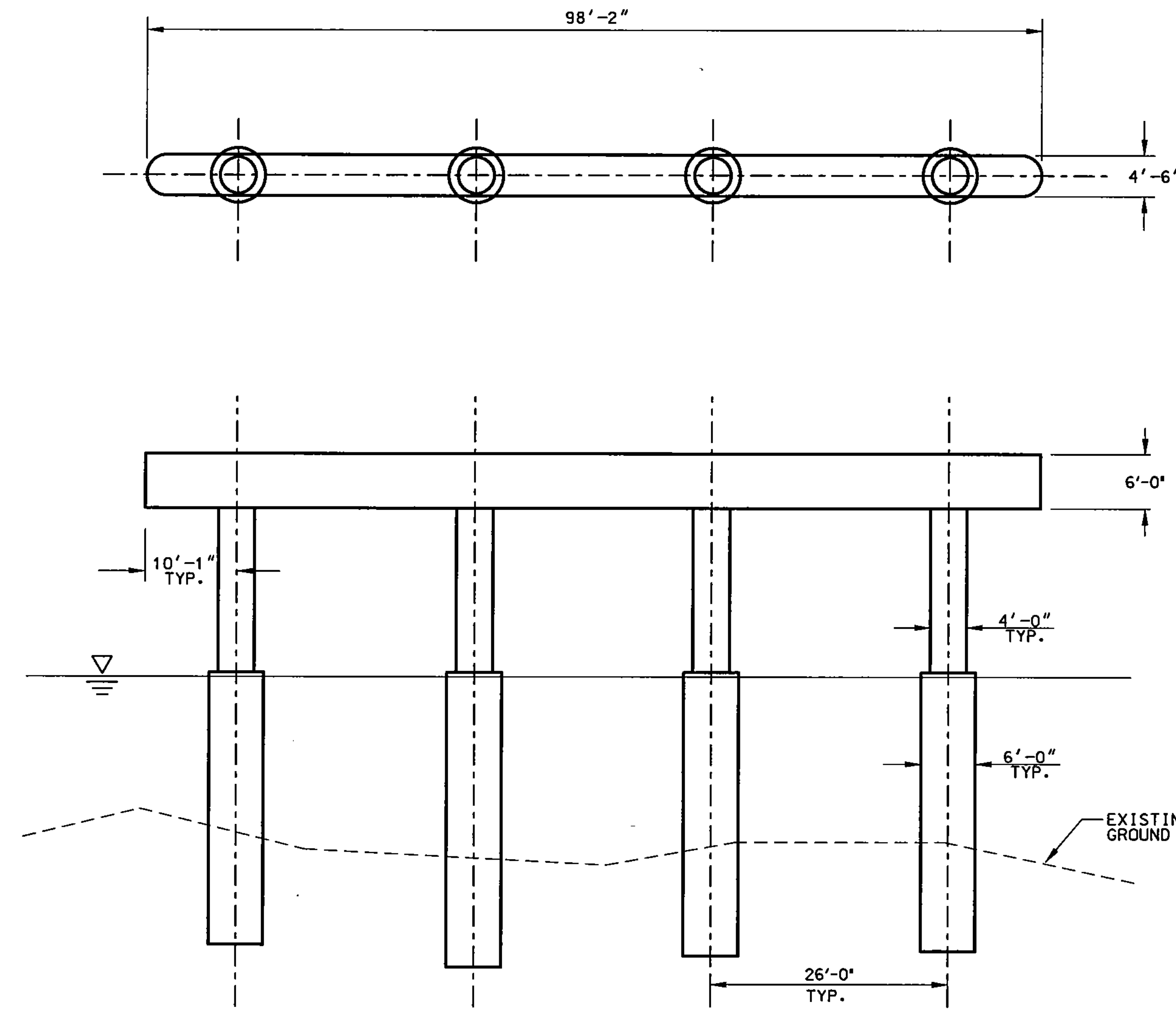
SUBSTRUCTURE OPTION A

SCALE: 1"=20'

OPTION A QUANTITIES

DESCRIPTION	QUANTITY •	UNIT
STRUCTURAL CONCRETE	632	YD^3
REINFORCING STEEL	139,040	LB

• QUANTITIES ARE PER PIER AND BASED ON AN AVERAGE HEIGHT FROM TOP OF PIER CAP TO TIP OF SHAFT OR PILE OF 72'.



SUBSTRUCTURE OPTION B

SCALE: 1"=20'

OPTION B QUANTITIES

DESCRIPTION	QUANTITY •	UNIT
STRUCTURAL CONCRETE	336	YD^3
REINFORCING STEEL	73,920	LB

• QUANTITIES ARE PER PIER AND BASED ON AN AVERAGE HEIGHT FROM TOP OF PIER CAP TO TIP OF SHAFT OR PILE OF 72'.

NOTE:

1. THE SUBSTRUCTURES SHOWN ARE CONCEPTUAL ONLY. THE SUBSTRUCTURE ELEMENTS WOULD BE ADJUSTED TO BEST FIT THE TERRAIN AND FINAL DESIGN REQUIREMENTS.
2. DRILLED SHAFTS OR PILES WOULD BE SOCKETED OR EMBEDDED IN COMPETENT ROCK.

PRELIMINARY - NOT FOR CONSTRUCTION

UTAH DEPARTMENT OF TRANSPORTATION
REGION 4, RICHFIELD, UTAH
HDR ENGINEERING, INC.

US-191 OVER COLORADO RIVER
COLORADO RIVER BRIDGE STUDY
SUBSTRUCTURE OPTIONS

PROJECT NUMBER BRF-0191(23)128

REVISIONS

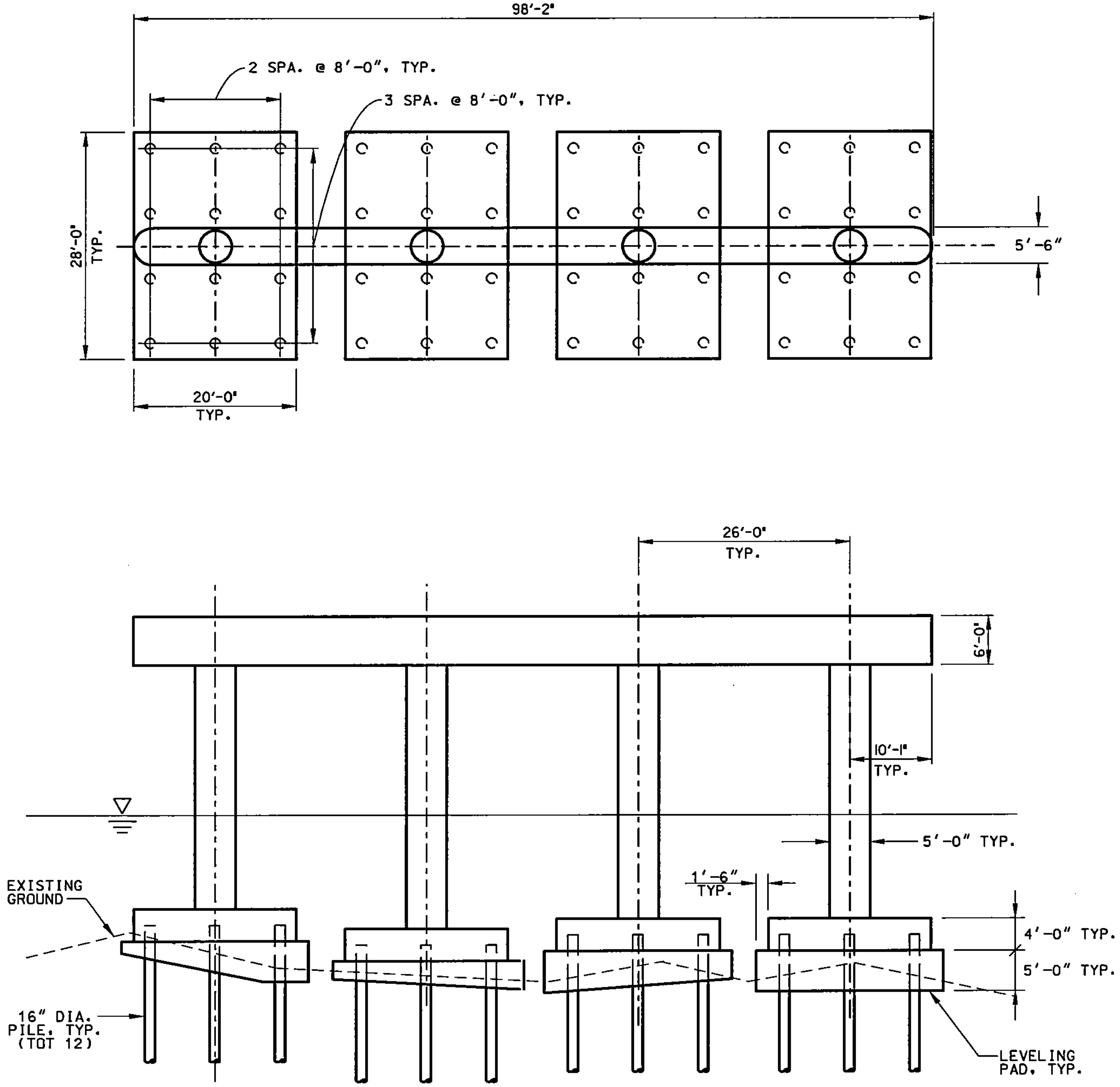
NO.	DATE	BY	REMARKS

DESIGN ____ CHECK ____
DRAWN ____ CHECK ____
QUANT. ____ CHECK ____
APPROVAL RECOM. ____ DATE ____ SENIOR DESIGN ENGR.
APPROVED FOR USE BY UDOT ____ DATE ____ UDOT BRIDGE ENGR.

GRAND
COUNTY

DRG. NO.

SHT. 25



SUBSTRUCTURE OPTION C

SCALE: 1"=20'

OPTION C QUANTITIES

DESCRIPTION	QUANTITY •	UNIT
STRUCTURAL CONCRETE	1050	YD^3
REINFORCING STEEL	231,000	LB
DRIVEN PILES	1920	FT

• QUANTITIES ARE PER PIER AND BASED ON AN AVERAGE HEIGHT FROM TOP OF PIER CAP TO TIP OF SHAFT OR PILE OF 72'.

PRELIMINARY - NOT FOR CONSTRUCTION

NOTE:

1. THE SUBSTRUCTURES SHOWN ARE CONCEPTUAL ONLY. THE SUBSTRUCTURE ELEMENTS WOULD BE ADJUSTED TO BEST FIT THE TERRAIN AND FINAL DESIGN REQUIREMENTS.
2. DRILLED SHAFTS OR PILES WOULD BE SOCKETED OR EMBEDDED IN COMPETENT ROCK.

REVISIONS

NO.	DATE	BY	REMARKS

UTAH DEPARTMENT OF TRANSPORTATION
REGION 4, RICHFIELD, UTAH
HDR ENGINEERING, INC.

DESIGN ____ CHECK ____
DRAWN ____ CHECK ____
QUANT. ____ CHECK ____
APPROVAL RECOMM. ____ DATE ____ SENIOR DESIGN ENGR.
APPROVED FOR USE BY UDOT ____ DATE ____ UDOT BRIDGE ENGR.

US-191 OVER COLORADO RIVER
COLORADO RIVER BRIDGE STUDY
SUBSTRUCTURE OPTIONS

PROJECT NUMBER BRF-0191(23)128

GRAND
COUNTY

DRG. NO.

SHT. 26

This page is intentionally blank.